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A FACTORIAL STUDY OF FLUENCY IN WRITING*

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A factorial study of fluency was undertaken to test an hypothesis that at least two fluency abilities would be measured by a battery composed both of word fluency tests used by Thurstone and tests of fluency described by several British investigators. Twenty-eight tests, including ten reference tests for five primary mental abilities, were administered to 181 high-school seniors. Ten centroid factors were extracted, a simple structure was found, and eight factors were interpreted. Five factors defined were the following reference abilities: memory (*M*), number (*N*), reasoning (*R*), verbal comprehension (*V*), and perceptual speed (*P*), the last one being somewhat tentatively identified. The main finding is the analysis of fluency into two factors: word fluency (*W*) and ideational fluency (*F*). Word fluency is defined as a facility in producing single, isolated words that contain one or more formal restrictions, without reference to the meaning of the words. Ideational fluency is described as a facility in expressing ideas by the use of words and their meanings. Another verbal ability indicated is tentatively interpreted as verbal versatility, the ability to express essentially the same idea by means of several different words or combinations of words.

I. *Introduction*

There have been several studies of fluency in which factor techniques or other experimental methods have been applied. Some of the main investigations have been made by the Thurstones (17, 18, 20), by Carroll (1), by Johnson and Reynolds (10), and by several contributors to British journals, including Cattell (3, 4), Hargreaves (8), Notcutt (13), Stephenson (14), and Studman (15). In these studies numerous tests have been described and defined as measures of fluency.

In Thurstone's first study (17) and particularly in the Thurstones' latest study (20) concerning fluency, a clear separation between verbal comprehension ability (*V*) and word fluency ability (*W*) was indicated. The word fluency factor was described as the ability to produce words in accordance with some restriction, as dis-

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tinguished from the ability to understand words when they are given in a test. The following types of tests proved to be the best measures of word fluency: Prefixes, First Letters, First and Last Letters, Four-Letter Words, and Suffixes.

The concept of fluency as discussed by various British investigators has been very broad, apparently including facility both in speech and in writing and also bearing a close relation to a general temperamental factor which Cattell named Surgency. This relation is considered to be sufficiently high for results in written fluency tests to be interpreted in terms of temperament; in fact, Cattell has stated that, of all the objective tests yet discovered for testing temperament, none are so valid as are the fluency tests for Surgency.

Cattell and Studman seemed to agree quite closely in their description of fluency. Studman also favors the term "Surgency" as the one that best describes the nature of the trait being measured by fluency tests. Other discussions of fluency mention the functioning of critical-mindedness, self-criticism, and "inhibitions at lower levels," plus a surging pressure of mental activity which, especially in more fluent persons, counteracts and readily overcomes these hindrances to expression (15).

Hargreaves (8) reported fluency of imagination to be a complex factor consisting of "*g*" plus memory plus speed plus "*x*," the nature of "*x*" and of speed being not clear, but probably best to be described in conative terms, namely, as an absence of self-criticism, which might lead to a preference for quantity over quality. More recently Notcutt (13) has claimed to have confirmed the existence of a group fluency factor, but did not find it to correlate with self-ratings of Surgency, at the same time pointing out the inadequacies of these ratings.

The fluency tests used in the British studies include the following types: Words beginning with *S*, Four-Letter Words, Two-Syllable Words, Subsumption (to list things that are round, little, etc.), Topics (to write as much as possible about a vague topic such as "a dog barking," "a parcel," etc.), Adjectives, Form Completion, and Ink Blots. It is evident that the first of these tests are very similar to some of Thurstone's best measures of word fluency.

In 1941 when the present study was planned, Thurstone had isolated and interpreted only two factors which were considered to be essentially verbal in nature, namely, *V* and *W*. It appeared improbable that the word fluency factor, *W*, was adequate to explain the individual differences found in speaking and in writing. In fact, Thurstone stated, in interpreting *W*, that people who excel in this ability might be expected to be clever with words and facile in speaking and

writing, but that effective oral and written language might also depend upon other factors.*

Strong evidence that language behavior is too complex to be described by a very small number of factors is found in the wide variety of symptoms, plus the numerous combinations of these symptoms, that have appeared in aphasic patients.

Accordingly, it seemed quite probable that at least two different psychological processes might be involved in a battery including tests of Thurstone's word fluency and tests used in different British studies of fluency. One possible hypothesis was that the ability needed in producing words in sentence form might be different from one required in listing isolated words where one word has no particular bearing on the next one. Another hypothesis was that the ability required in listing words that fall within certain arbitrary constraints may be different from one involved when words are produced according to their meanings.

In testing the above hypotheses it would also be possible to determine what relation existed between Thurstone's word fluency factor and the fluency factor found by means of different factorial methods by British investigators.

It was decided that a factorial study using Thurstone's techniques would provide the best method of testing the hypotheses on fluency. In order to insure that any new factors found would be different from the primary mental abilities isolated in previous investigations, it was decided to include in this study, as reference factors, all of these abilities which might conceivably be pertinent to fluency. Ideas for the experimental tests were mainly taken from the literature, and adaptations were made so that each test would be in a form most suitable for the problem under investigation. All tests in the battery required either a recognition or a written type of response.

Carroll's factorial study of verbal abilities (1) appeared in the literature after the design of the present experiment had become fairly crystalized. His factor *A* is somewhat similar to the word fluency factor *W* and is discussed in some detail later. The flow of responses factor found in the verbal study by Johnson and Reynolds (10) is also relevant to the present study and will be mentioned later.

II. *The Tests*

A complete list of the tests in the battery is contained in Table 1. This table also shows the ten tests used to measure reference abilities

* This interpretation was given with primary mental ability scores to subjects who participated in the perceptual investigation by L. L. Thurstone in 1941-2.

in this study. All reference tests are the same as or similar to ones used previously by the Thurstones (20) in the eighth-grade study, but the time limits may differ from those set for the eighth-grade sample. In addition, tests 11 to 16 have also been used in the present form or in a similar form in the eighth-grade study and in various other studies by Thurstone.

Before the fluency tests were administered, general instructions were given *not* to write proper nouns (including proper names), foreign words, or plurals on any of the word-listing tests. The tests used are described briefly below.

First Names (1).—This memory test contained 20 items, each consisting of a first and a last name, such as "Ruth Preston." Each name to be memorized was presented on a flash card. After each card had been exposed for 15 seconds in the front of the room, the subjects were required to check on the answer sheet the correct first name for the last name given.

Word-Number (2).—This memory test also was administered by flash cards. Each card contained a word and a two-digit number, such as "chair-21." After each of the 16 test cards had been exposed for 15 seconds, the subjects were told to turn to their answer sheet and mark the correct number for the word given in each item.

Identical Numbers (3).—This perceptual test consisted of 30 columns of three-digit numbers, each column having a key number and 29 numbers beneath it. The subjects were to mark the numbers in each column that were identical with the key number at the top of the column.

*Mirror Reading (4).**—This test consisted of 50 columns of five words. The first word in each column was printed forward and below it were four words printed backward (mirror image). One of the four words printed backward was the same as the first word in the column. The task in each column was to mark the word printed backward that was the same as the first word.

Letter Series (5).—This reasoning test contained 30 items. The subjects were asked to study each series of letters, decide what the next letter should be, and mark the letter in the answer row at the right. One sample series follows:

cadaea *fa* — *a* *c* *d* *e* *f* *g*

* In some investigations the Mirror Reading test has been called "Backward Writing."

Letter Grouping (6).—There were 30 problems in this reasoning test. A sample practice exercise was as follows:

Three of the groups of letters below are alike in some way. Can you find three groups which are alike? Mark the one that is different.

XVRM ABCD MNOP EFGH
_____ _____ _____ _____

Addition (7).—This number ability test consisted of 56 problems, each one containing a column of six two-digit numbers with a sum at the bottom of the column. The task was to mark whether the sum was right or wrong.

Multiplication (8).—This was a number ability test in which a two-digit number was multiplied by a one-digit number to give a product. The subjects marked whether the product shown was right or wrong.

Same or Opposite (9).—This verbal comprehension test consisted of 100 items. The subjects were asked to select from four choices the word that meant the same as or the opposite of the given word in each item.

Completion (10).—This was a test of verbal comprehension consisting of 41 items. A sample practice problem is given below to indicate the nature of the test.

The following sentence has a word missing at the place indicated by the parentheses. You are to think of the word that best completes the meaning of the sentence.

A (4) is a contest of speed.

b _____ c _____ m _____ r _____ t _____

The missing word is *race*. The number in the parentheses is the number of letters in the missing word. The letter *r* has been marked because it is the first letter in the missing word.

First and Last Letters (11).—The test instructions were to write as many words as possible which *begin* with *T* and *end* with *E*.

Suffixes (12).—In this test the subjects were asked to write as many words as they could which *end* with *tion*.

Synonyms (13).—The subjects were told to write three synonyms for each of the 18 words (e.g., dark, expensive, happy, etc.) given in this test.

First Letters (14).—The instructions were to write as many words as possible that *begin* with *S*.

Anagrams (15).—In this test the subjects were told to write as many words as they could using the letters in the given word, ABBREVIATION.

Disarranged Sentences (16).—This test consisted of 81 sentences in which the words were jumbled up. If the words were properly rearranged, they formed a statement which was either true or false. The subjects were asked to mark whether each disarranged sentence was true or false. One sample sentence was: "eyes some brown are."

Adjectives (17).—In this test the subjects were asked to write all the adjectives that they could possibly use to describe a *house*.

Similes (18).—Fifteen incomplete similes were listed in the test and the subjects were to write three ways (using words or phrases) in which each simile could be completed. A sample exercise was as follows: "His skin was as brown as"

Paired Opposites (19).—The subjects were asked to write pairs of opposites in each double blank on the test. *No* leads, such as first letters or first words, were presented.

Letter Star (20).—This test contained the 75 items developed and used by Carroll (1). The subjects were told that they would be given a group of letters and stars such as "* P * H." Each group could represent a sentence, a phrase, a question, or any other meaningful arrangement of words. Each letter or star stands for the first letter of a word. The star can be any letter in the alphabet. An example with one possible answer is shown below.

W * * C — Where is the candy?

Unfinished Stories (21).—This test was essentially the same as one used by Hargreaves. The subjects were asked to write a clear, meaningful continuation of a story from a given beginning which was as follows: "Once upon a time a boy was so late coming home from school that his parents became very worried. At last he arrived home safely, though very tired, but with his cap and one boot missing. He told them what had happened, which was this: When he left school"

Number of Letters (22).—This test was similar both to a Four-Letter Words test used by the Thurstones and to a Four-Letters sub-test used by Studman. The test instructions were to write as many words as possible that have *three letters*.

Topics (23).—The subjects were required to list many ideas for

one topic instead of a few ideas for each of several topics as in a Topics test used in British studies. The following directions were given:

Often, as in conversations, it is good to have many ideas about a topic. See how many ideas you can think of about the topic you are to be given. Be sure to list all the ideas you can about the topic whether they seem trivial or not. You are not limited to one word. Instead you may use a phrase to express each idea.

The topic used was "A man going up a ladder."

Given Letters (24).—The task was to write as many words as possible that conformed with the one restriction, namely, that each word must contain the letters *R* and *M*. No restriction on the position of these letters or on any other aspect of the words was imposed.

Sentence Fluency (25).—The subjects were to write a variety of different sentences, each one stating essentially the same general idea. The test problem follows:

Suppose that in a certain campaign you were canvassing for a candidate, Mr. Jones. You want to write several of your personal friends and tell them to vote for Mr. Jones. You want to state this thought in a single sentence. Yet you want to write a different sentence to each of your friends. Write as many different sentences as you can that serve this purpose. Limit each sentence to one line.

Things Round (26).—This test was similar to one used by Catell (5) in which the subjects were asked to list words that were appropriate for each of several successive categories. In the present test the category was "things that are round or that could be called round."

Things to Eat (27). — The subjects were asked to list all the things they could that came within the category, "things to eat."

Theme (28).—The test directions are given below.

In this test you are to write about a given topic. Be sure to write all you can about this topic. Use all the ideas you can think of whether they seem trivial or not. Expand on any idea as much as you like. When you have written all you can about an idea, start a new paragraph and write on another idea about the topic. Just be sure to write as much as you can about this topic.

The topic for the test was "a pareel."

III. *Procedure and Results*

Three groups of high-school seniors from Central, Eastern, and Roosevelt High Schools in Washington, D.C., were tested in this study with the battery just described. Students who did not take all the tests were eliminated from the sample, leaving a total of 181 cases

with complete data: 58 students from Central, 52 from Eastern, and 71 from Roosevelt. These 181 seniors, then, formed the sample on which the study was based. The testing was done in November, 1941, a few weeks after the students had started their senior year.

The test battery was administered to each group of students in a two-hour session on each of two successive days. A brief rest period was allowed each day after the first hour of testing.

Intercorrelations between the tests were obtained by means of the Pearson product-moment formula. These correlations are shown in Table 2. The ten factors extracted from the correlation matrix are contained in the centroid matrix of Table 3. The communalities for the tests are listed in the last column of this table.

After nine factors had been obtained, the critical value of a criterion suggested by Coombs (6) for determining the point at which factoring can be terminated had been reached. However, in order to be doubly certain that an adequate number of factors had been obtained, a tenth factor was extracted. The numerical values of the final residuals ranged from .06 to -.07. The root-mean-square deviation of these residuals from zero was .023.

A simple structure was found by using both the single plane (19) and the radial methods of rotation. The final solution obtained is presented in the rotated factorial matrix, Table 4. Examination of this table and of the plots of its factors indicates that a clear simple structure was found. On every factor more than half of the entries were zero entries (projections from .10 to -.10), the number of zero entries ranging from 16 to 24 for the ten factors. There were no large negative values, the projection of -.13 being the only one that was larger than -.10.

The transformation from the centroid matrix to the rotated factorial matrix is given by the final transformation matrix in Table 5. The cosines of the angles between the reference vectors are contained in Table 6. The correlations between the ten primary factors in the simple structure are shown in Table 7. It should be noted that the correlations were generally quite low between the five reference factors and the two new verbal factors, F and K.

In order to present the simple structure more clearly and to facilitate the process of interpretation, a matrix showing the factorial pattern is given in Table 8. This pattern matrix was obtained by omitting all entries below .30 from the rotated factorial matrix (Table 4) and then rearranging the order of the rows (the tests). The structure thus presented is quite clear, showing practically no overlap among the first seven factors listed. A check was made to see what

additional entries would occur in the factorial pattern if the limit were lowered to include entries from .25 to .29, inclusive. It was found that there would be additional entries only in Factor *P*, which had only one entry above .30, and in Factor *C*, which was not interpreted.

Further inspection of the factorial pattern indicates that, except for the Word-Number test, none of the reference tests (tests 1 to 10) had appreciable loadings on any but the first five factors; and except on Factor *P*, at least two of these reference tests had projections above .30 on each factor. Furthermore, 16 of the 18 experimental tests (tests 11 to 28) did not have loadings on any of the first five factors, but these 16 tests all had an appreciable projection on at least one of the next three factors, *W*, *F*, or *K*. These three factors were strongly determined structurally in terms of the number of tests with high loadings as well as in terms of the number of tests with zero entries.

IV. Interpretation

Factor M.—Two tests had projections above .30 on this factor. They were the First Names test (1), with a projection of .59, and the Word-Number test (2), with one of .34. Factor *M* is interpreted as *memory reference ability*, that is, rote learning of simple associations with immediate recall. The flash card method of presentation on these tests was different from the usual presentation of items in booklet form. Nevertheless, the memory ability (*M*) did appear clearly in the simple structure, and no correlations above .23 were found between it and other primary factors in this study.

Factor P.—The only test with a high loading on this factor was Identical Numbers (3), with a projection of .49. The other test selected in addition to Identical Numbers as a perceptual reference test was Mirror Reading (4), which had a loading of .28 on this factor. Its main loading appeared on factor *R*. Most other tests with loadings (.28 or .27) on factor *P* have some perceptual requirements. These tests include Multiplication (8), Anagrams (15), Disarranged Sentences (16), and Synonyms (13). Synonyms is the only one without some obvious perceptual characteristics. Consequently, factor *P* is tentatively interpreted as a *perceptual speed factor*, although this identification is not as strongly supported as is desirable.

Factor R.—The three tests that had high projections on this factor were the Mirror Reading test (4), with a projection of .55; the Letter Series test (5), with one of .49; and Letter Grouping (6), with one of .47. Factor *R* is interpreted as the *reasoning ability reference factor*, since the two reference reasoning tests had high loadings on it and no appreciable loadings on any other factor.

The appearance of Mirror Reading on this factor warrants some explanation. Inspection of this test indicates that it could be quite susceptible to different methods of solution. Some may be a combination of reasoning and perceptual methods while others may be more strictly perceptual in nature. For example, one or more of the wrong choices could be quickly eliminated by finding a simple rule and applying it to the mirror-image words. One such rule is that all mirrored words end with the same letter; only the beginnings of the mirrored words need, therefore, be examined. As one worked further, he might notice that in most cases only the first two mirrored letters need be inspected to determine the correct answer. By means of these rules a great deal of the perceptual task could be eliminated and the remaining perceptual task greatly simplified. Mirror Reading had a higher loading on *P* in the eighth-grade study, at which level students would probably less likely utilize the above rules in their work method on this test. .

Factor N.—Three tests had appreciable loadings on this factor, the Multiplication test (8), with a loading of .71; the Addition test (7), with one of .59; and the Word-Number test (2), with one of .30. Factor *N* is interpreted as the *number facility reference factor*. The only other test with a loading above .07 on this factor was also a test employing number symbols, namely, the Identical Numbers test (3), with a projection of .24.

Factor V.—The following tests had high loadings on this factor.

9. Same or Opposite .....	.74	16. Disarranged Sentences ....	.60
10. Completion .....	.74	19. Paired Opposites .....	.43

Factor *V* is interpreted as the *verbal comprehension reference factor*. This ability is more one of recognition than of recall; and the meaning of sentences and also the meaning of, and the relation between, pairs of words are its particular field. The same ability is apparently required in the recognition of pairs of words that have the same or the opposite meaning as in the production of pairs of words that have opposite meanings.

Factor W.—The following tests had high saturations on this factor.

11. First & Last Letters .....	.56	24. Given Letters .....	.43
12. Suffixes .....	.50	22. Number of Letters .....	.38
14. First Letters .....	.48	15. Anagrams .....	.36

This factor is interpreted as *word fluency ability*, a facility in producing single, isolated words that contain one or more formal re-

strictions, without reference to the meaning of the words. Words are selected and produced through a process based upon their structure rather than upon their meaning.

There have been some indications and statements before that meaning requirements are minimized in the word fluency factor.* This study, however, shows clearly that the meaning of words is not involved in *any* of the six tests that had appreciable loadings on the *W* factor. There were only six word-listing tests in the battery with purely formal restrictions and *all* these tests, and *only* these tests, had appreciable projections on this factor.

A comparison between the First and Last Letters test and the Given Letters test indicates that a word-listing test with two or three well-defined structural restrictions will be a better measure of word fluency than a test with only one formal restriction, permitting a wider variety of work methods. Further support for this conclusion is found in the fact that the Number of Letters test (to write three-letter words) did not have in this study as high a projection on *W* as did the Four-Letter Word test in the eighth-grade study. In the latter test, not only the number of letters but also the first letter was specified.

In some respects this factor differs from Carroll's factor *A* (1), which was described as the speed of word association (usually of common words) where there is some element of restriction in the task imposed; i.e., where only one or a certain number of responses from the total word reserve are correct. In interpreting his factor, Carroll made no reference whatsoever to the meaning of the words. There were also some tests with loadings on his factor which had restrictions such that only one response per item was correct. On the other hand, in the present study all the word fluency tests imposed restrictions so broad as to allow a large pool of words (e.g., all words that begin with "S") to meet the test requirements. On all tests the subjects were given only one general task, which was, in essence, to produce from this pool of appropriate responses as many words as possible within the time allotted. It is thus believed that any test allowing only one correct response per item would not be one of the

* The best example of such statements is found in the interpretation of primary mental ability scores given by L. L. Thurstone to the individuals who served as subjects in his factorial study of perception in 1941-2. The interpretation began as follows: "*W*—Word Fluency, which is represented in tests requiring the fluent production of words in various contexts independent of the meaning involved." However, some of the strength of this initial statement regarding the role of meaning is lost in his further description, one sentence later, of word fluency. "People who excel in this ability might be expected to be . . . facile in speaking and writing. Effective oral and written language may also depend upon other factors."

better measures of word fluency.

Factor F.—The following tests had loadings above .30 on this factor.

28. Theme .....	.50	17. Adjectives .....	.41
23. Topics .....	.50	21. Unfinished Stories .....	.41
25. Sentence Fluency .....	.49	27. Things to Eat .....	.33
26. Things Round .....	.43	18. Similes .....	.31

Factor *F* is interpreted as *ideational fluency ability*, a facility in expressing ideas by the use of words and their meanings, quantity and not quality being the important thing. The quality of the material produced need only come within the limits of the meaning requirements of the test as interpreted by the subject. In the tests, words are produced through an associational process based on their meanings. The words are used as a means to an end, as tools in the expression of ideas. It should be noted that a person could obtain a good score in most of these tests by using relatively simple and common words.

The ideational fluency ability is measured in some cases by the number of words and in other cases by the number of phrases or sentences produced. It includes the production of meaningful phrases and sentences and also the listing of words where some meaning is required. The words written stand in some meaningful relation to other words written or implied.

Factor *F* in some respects is similar to, but also is rather different from, Carroll's factor *E* (1), which was interpreted as the rate of production of meaningful and syntactically coherent discourse where there is little restriction to definite responses. For example, Anagrams had a loading of .31 on Carroll's factor *E*, but failed to have an appreciable projection on his word fluency factor *A*. In the present study, however, Anagrams had a zero loading on factor *F*, but had a projection of .36 on the word fluency factor. Other tests with appreciable projections on Carroll's factor *E* were Theme (number of words), Grammar, Similes, Picture Description (per cent relevant words), and Distorted English.

The directions on all tests on the present factor stressed quantity and not quality or coherence. Carroll's Theme test was scored in three different ways and his Picture Description test was scored in four ways, some scores being essentially measures of quantity while others measured the quality of the responses. Consequently, the directions on these two tests could not have stressed only the quantity of the responses. The fact that a second score on the Picture Description test, the number of relevant words, did not have a high loading on

Carroll's factor *E*, is pertinent at this point. Carroll states that this Picture Description score did not have an appreciable projection on factor *E* "because, it is believed, it is not directly a measure of coherence, but only a measure of the amount which the subject had to say." The present factor, however, is interpreted as measuring essentially the amount that the subject could express about a topic. In Topics and Theme, two of the best tests of this factor, the subjects were told explicitly to use all the ideas that they could think of, whether they seemed trivial or not.

Factor K.—The tests below had projections above .30 on this factor.

18. Similes .....	.51	21. Unfinished Stories .....	.33
20. Letter Star .....	.51	13. Synonyms .....	.32
25. Sentence Fluency .....	.40		

It is possible that some of the variance on these tests can be attributed to individual differences in the ability to produce rapidly more than one answer that will satisfy the fairly restrictive requirements of each test. The factor may be tentatively interpreted as *verbal versatility*, the ability to express essentially the same idea by means of several different words or combinations of words. Thus, in the Similes, Sentence Fluency, and Synonyms tests, a person who is good in this ability can readily break the set of the first answer and produce a second answer, and then a third answer, that expresses the same general meaning. Others may find it difficult to break away from the first answer to restate the same idea in a somewhat different form. A task of rewriting certain phrases, sentences, or even paragraphs, would be relatively easy for a person excelling in this ability.

It is likely that a related process occurs in the Letter Star test. Inasmuch as the series of words must be meaningful sentences or phrases and must also fit certain first-letter and number-of-word requirements, it is probable that subjects solve this test in the following manner: first, they produce a meaningful series of words according to some initial association, and then they alter the words used or the idea expressed until they arrive at an appropriate series of words. This type of revision might take place on each item where the first attempt is not completely appropriate, or it may even occur in the course of producing words in the first attempt.

The only explanation that could be found for the appearance of Unfinished Stories on this factor was that some revision process may be needed in this test to insure that the various details given in the beginning are properly included in the different stages of the story.

and also to insure that the story would not be concluded before time was called.

Factors C and E were not strongly determined and did not lend themselves readily to psychological interpretation, so no interpretation is given.

V. Discussion

The hypothesis that fluency is complex and that at least two factors would appear in the experimental portion of a battery including word fluency tests used by Thurstone and fluency tests used by British investigators was sustained. It is evident from the results that the tests of fluency used in British studies measure at least two quite separate fluency abilities, *W* and *F*, the correlation between which was $-.03$. Tests of these two types have nearly always been combined in the same fluency battery assembled by different British investigators. For example, Cattell (5) had a fluency battery which included tests the same as or similar to First Letters, Topics, Things Round, Things to Eat, and Theme; and Studman (15) used a battery containing tests similar to Adjectives and Number of Letters plus a Two-Syllable test which would probably measure word fluency.

The two fluency factors obtained in the present study have been interpreted strictly in terms of cognitive processes. Inasmuch as the ideational fluency factor involves the amount that a person can express about a given topic and measures indirectly the flow of ideas, it is probably of more fundamental importance to language behavior than the word fluency factor, which involves the handling of words solely in terms of their structure.

Another possible distinction between the two fluency factors may be made in terms of a reported "tendency to be critical-minded." Stephenson described this critical-mindedness as the way in which one individual demands perfection whereas another is satisfied with less. In word fluency tests it is believed that any effects of critical-mindedness are minimized, for the subject has little or no freedom to form an individual conception of what responses would be appropriate. On the other hand, in the ideational fluency tests the subject has a great deal of freedom to establish his own conception of what answers are suitable. Thus, in the latter tests there is a possibility for the presumed critical-mindedness in an individual to operate with considerable effect.

There seems to be some similarity between the concept of surging mental activity operating against the screening barrier of critical-mindedness (or "inhibitions at lower levels") and the concept of

Johnson and Reynolds (10)* of two fundamental processes involved in verbal problem-solving, namely, the *flow* of various acts or responses and the *selection* of those responses which meet the requirements of the problem. Johnson and Reynolds state that possibly their flow factor is the same as the word fluency factor and their selection factor may be the usual verbal factor *V*. They also suggest that the two processes of flow and selection of responses might also be found in non-verbal problem-solving tasks. One might argue that a flow of responses is needed in some tests found in the present, quite separate factors *R*, *V*, and particularly in *W*, *F*, and *K*; and that a selection of responses, either a recognition selection or a screening selection, is functioning in tests found in every interpreted factor of the present study. Consequently, it is believed that although flow and selection of responses may be important aspects in the solution of some mental tasks, neither of them function at a highly significant level throughout a wide range of either verbal or non-verbal tests. In other words, it is believed that the flow of response in word fluency tasks and the flow of response in ideational fluency are not the same basic process. Likewise, the flow and selection of responses in reasoning (*R*) tests are likely different processes from the flow and selection of responses functioning in other tests, such as tests found in factors *F* or *K*.

Studman (15) and Stephenson (14) have reported that a battery of fluency tests has given indications of identifying some psychiatric types, especially manics. However, their batteries contained tests of each type of fluency found in the present study. The question thus arises as to the relation between each of these fluency abilities and different types of psychiatric cases.

There is some indication that ideational fluency cuts across both oral and written channels of expression. For example, according to Studman's findings, manics in their ideational flight are not only very fluent in speech but also can express themselves quite readily in written tests. Further study is needed on ideational fluency and also on word fluency to see if either of these factors transcends expression in writing and is present in oral expression. The verbal versatility factor needs to be studied to see if it will be substantiated further at the writing level. This factor should also be checked to see if it enters into oral expression.

More studies should be undertaken to compare the abilities involved in producing high quality written or spoken language with the fluency abilities that operate in quantity production. Studies

* The Paired Opposites test was taken from this study.

should also be made of the abilities that function in the comprehension of spoken language.

It is believed that the main verbal abilities indicated to date are verbal comprehension (*V*), word fluency (*W*), ideational fluency (*F*), verbal versatility, and Carroll's factor *H*, which is described as a facility in attaching appropriate names or symbols to stimuli.

Carroll's factor *H* (1) seems to bear a close relation to the symptoms displayed by amnesic aphasics. This is an important indication, since the category of amnesic aphasia is one of the few usually found in most classifications of aphasia.

Factorial studies of verbal and non-verbal abilities can have an important bearing on future investigations of aphasia. Weisenberg and McBride say that in studying aphasics the results on tests are significant only so far as the examiner can determine what processes are involved in working the test. Since such tests have not yet been developed in sufficient variety to cover the whole field of mental functioning, they point out that temporarily, at least, every investigator has to employ tests not altogether satisfactory for the analysis of the processes involved (21, p. 89).

Factorial studies tend to identify more clearly the processes involved in mental tasks and thus give indications of important symptoms to look for in further studies of aphasia. On the other hand, results obtained in investigations of aphasia may provide substantiation for factorial results. For example, in speaking of the re-education of aphasic patients, Huber (9) mentions that some difficulty is encountered with patients showing recurrent utterances. Such utterances seem to be greatly influenced by the position of the speech mechanisms for the initial vowel or consonant in the words repeated. It is consequently possible to teach these patients to express a new word by selecting one with the same beginning sound as that in a recurrent word and by having the patient substitute this new word for the recurrent one. Then other words with the same and with different initial sounds can be substituted. After this, Huber further says that abstract words can be introduced in the form of propositions. This therapeutic technique seems to utilize initially a process similar to that of word fluency for breaking down the recurrent utterance, followed by a process of learning words in terms of propositional speech, which is essentially the way that words are used in the ideational fluency ability.

Another example particularly relevant to the present study is taken from a recent book on aphasia by Nielsen. Inasmuch as the clinical testing methods used in his investigation did not include exactly

the same type of tasks as contained in the present fluency tests, the most direct evidence on fluency abilities that would be desirable on aphasics is not yet available. Nevertheless, some support for the separation of fluency into the two factors, word fluency and ideational fluency, can be obtained from Nielsen's statement that "significance is still not reminiscence; it is a higher function because one can recall a word of which the significance is unknown" (12, p. 73).

TABLE 1
The Battery of Tests*

Test No.	Test Name	Refer- ence Factor	Time Limit (min.)	Scoring Formula	Test- ing Order
1.	First Names	M	3-2-7	5	No. right
2.	Word-Number	M	3-2-6	4	No. right
3.	Identical Numbers	P	2	4	No. right
4.	Mirror Reading	P	3	2 $\frac{1}{2}$	No. right
5.	Letter Series	R	5	4 $\frac{1}{2}$	No. right
6.	Letter Grouping	R	6	3 $\frac{1}{2}$	No. right
7.	Addition	N	3	6	No. right
8.	Multiplication	N	2	4 $\frac{1}{2}$	No. right
9.	Same or Opposite	V	2	4 $\frac{1}{2}$	No. right
10.	Completion	V	2	4 $\frac{1}{2}$	No. right
11.	First and Last Letters .....	...	3	4	No. words
12.	Suffixes .....	...	2	4	No. words
13.	Synonyms .....	...	3	3 $\frac{1}{2}$	No. words
14.	First Letters .....	...	2	3 $\frac{1}{2}$	No. words
15.	Anagrams .....	...	3	4	No. words
16.	Disarranged Sentences .....	...	3	4	No. right
17.	Adjectives .....	...	2	4	No. words
18.	Similes .....	...	2	5 $\frac{1}{2}$	No. phrases
19.	Paired Opposites .....	...	1	4	No. pairs
20.	Letter Star .....	...	2	9	No. phrases
21.	Unfinished Stories .....	...	1	7	No. words
22.	Number of Letters .....	...	2	3	No. words
23.	Topics .....	...	2	5	No. phrases
24.	Given Letters .....	...	2	3 $\frac{1}{2}$	No. words
25.	Sentence Fluency .....	...	3	7	No. sent.
26.	Things Round .....	...	2	2 $\frac{1}{2}$	No. words
27.	Things to Eat .....	...	—	2 $\frac{1}{2}$	No. words
28.	Theme .....	...	1	6	No. words

* Most of the subjects also completed a personality scale, "An Inventory of Factors STDCR," by J. P. Guilford. A later paper is planned in which the scores on these personality measures will be compared with composite scores on the main cognitive factors found in this study.

TABLE 2
Product-Moment Correlations between the Tests*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	...	35	02	15	22	28	02	11	21	18	09	23	14	12
2	35	...	04	14	20	24	20	22	16	10	17	18	13	26
3	02	04	...	37	35	28	22	43	29	20	19	17	26	25
4	15	14	37	...	47	45	21	22	26	24	13	10	20	22
5	22	20	35	47	...	53	23	27	47	41	20	29	33	33
6	28	24	28	45	53	...	23	24	37	38	31	29	28	31
7	02	20	22	21	23	23	...	62	09	07	22	22	02	18
8	11	22	43	22	27	24	62	...	25	13	20	17	16	24
9	21	16	29	26	47	37	09	25	...	76	22	32	43	41
10	18	10	20	24	41	38	07	13	76	...	26	35	40	37
11	09	17	19	13	20	31	22	20	22	26	...	49	30	43
12	23	18	17	10	29	29	22	17	32	35	49	...	35	55
13	14	13	26	20	33	28	02	16	43	40	30	35	...	47
14	12	26	25	22	33	31	18	24	41	37	43	55	47	...
15	20	26	33	34	35	40	18	28	31	24	35	35	40	52
16	21	10	31	22	36	37	07	23	72	63	19	32	45	40
17	10	13	18	03	13	11	-02	03	22	19	21	30	30	26
18	06	08	27	18	32	37	12	17	38	38	15	24	41	31
19	13	24	14	21	38	38	00	06	52	52	21	30	53	45
20	03	09	22	18	21	30	16	22	26	21	26	26	40	40
21	00	-07	18	16	22	25	19	29	18	13	-03	06	30	24
22	17	22	23	34	46	43	18	22	38	38	45	41	39	66
23	20	18	27	19	30	31	16	23	31	27	22	35	41	33
24	22	21	22	18	31	34	14	23	44	43	47	51	42	54
25	03	09	25	13	16	21	20	19	14	15	18	27	34	27
26	06	19	27	14	22	30	10	15	17	13	18	16	24	20
27	03	07	22	20	17	15	10	21	26	20	25	26	38	33
28	18	01	17	07	22	23	13	15	31	25	16	31	26	27

* The decimal point has been omitted for all entries.

Table 2—Continued

	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	20	21	10	06	13	03	00	17	20	22	03	06	03	18
2	26	10	13	08	24	09	-07	22	18	21	09	19	07	01
3	33	31	18	27	14	22	18	23	27	22	25	27	22	17
4	34	22	03	18	21	18	16	34	19	18	13	14	20	07
5	35	36	13	32	38	21	22	46	30	31	16	22	17	22
6	40	37	11	37	38	30	25	43	31	34	21	30	15	23
7	18	07	-02	12	00	16	19	18	16	14	20	10	10	13
8	28	23	03	17	06	22	29	22	23	23	19	15	21	15
9	31	72	22	38	52	26	18	38	31	44	14	17	26	31
10	24	63	19	38	52	21	13	38	27	43	15	13	20	25
11	35	19	21	15	21	26	-03	45	22	47	18	18	25	16
12	35	32	30	24	30	26	06	41	35	51	27	16	26	31
13	40	45	30	41	53	40	30	39	41	42	34	24	38	26
14	52	40	26	31	45	40	24	66	33	54	27	20	33	27
15	....	37	20	17	34	28	20	54	27	48	26	20	37	20
16	37	....	28	41	46	28	28	37	32	43	20	18	28	34
17	20	28	....	43	31	39	20	19	56	34	50	42	36	30
18	17	41	43	....	44	60	47	30	60	32	63	41	35	29
19	34	46	31	44	....	38	22	47	37	42	34	27	30	22
20	28	28	39	60	38	....	46	32	50	34	54	27	37	25
21	20	28	20	47	22	46	....	26	40	20	49	24	28	37
22	54	37	19	30	47	32	26	....	25	46	26	19	25	23
23	27	32	56	60	37	50	40	25	....	36	59	51	41	40
24	48	43	34	32	42	34	20	46	36	....	31	33	34	28
25	26	20	50	63	34	54	49	26	59	31	....	43	34	37
26	20	18	42	41	27	27	24	19	51	33	43	....	29	28
27	37	28	36	35	30	37	28	25	41	34	34	29	....	40
28	20	34	30	29	22	25	37	23	40	28	37	28	40	....

TABLE 3
The Centroid Factorial Matrix*

Test No.	I	II	III	IV	V	VI	VII	VIII	IX	X	h^2
1	28	-18	-10	-07	-03	41	11	13	-31	18	.452
2	30	-28	01	12	-06	23	44	05	-14	-03	.456
3	45	-14	15	-17	02	-12	-06	-33	12	12	.430
4	42	-29	00	-23	-27	-01	-17	-22	07	-07	.474
5	58	-25	-13	-29	-22	10	-07	-07	08	-05	.577
6	60	-25	-08	-21	-29	16	-10	13	08	-04	.618
7	33	-39	43	-18	19	-14	08	20	10	-11	.602
8	44	-34	41	-25	27	-27	18	01	-04	02	.720
9	65	11	-43	-34	20	-05	19	-06	06	-09	.829
10	59	12	-50	-30	15	00	11	09	19	-07	.786
11	47	-24	-09	34	20	02	-14	11	23	06	.531
12	56	-14	-14	23	29	11	-09	19	10	-14	.576
13	62	16	-18	11	-06	-15	02	-10	-05	18	.526
14	67	-16	-17	31	05	-18	-01	06	-08	-04	.646
15	60	-27	-09	20	-04	-11	-12	-18	-19	-06	.581
16	64	16	-34	-29	19	-11	09	-09	-10	-02	.710
17	48	36	15	25	07	23	-01	-14	07	03	.528
18	64	41	17	-08	-21	-06	03	12	19	08	.718
19	61	18	-29	10	-22	-05	24	00	03	-12	.622
20	59	25	20	11	-15	-21	-05	14	09	13	.576
21	45	26	27	-17	-18	-23	-18	17	-25	-05	.584
22	65	-27	-22	19	-16	-18	-06	09	-04	-14	.671
23	66	30	29	04	-04	25	02	-03	01	08	.683
24	66	-04	-19	24	17	05	-01	05	04	-03	.567
25	57	34	41	15	-14	-01	-06	13	08	-01	.678
26	47	19	26	08	-08	27	01	-13	08	-16	.459
27	51	19	11	14	10	-05	-15	-16	-14	-06	.412
28	47	20	08	-06	19	08	-24	09	-22	-11	.440
Σ	1496	-01	-01	-03	-06	-02	00	25	06	-52	

* The decimal point has been omitted for all factor loadings.

TABLE 4
The Rotated Factorial Matrix*

Test No.	M	P	R	N	V	W	F	K	C	E
1	59	02	06	00	-01	01	15	-04	01	-01
2	34	-05	00	30	03	-05	-04	-01	35	05
3	-04	49	23	24	01	-01	-05	05	00	-02
4	01	28	55	03	-02	-04	-05	-05	00	06
5	14	19	49	01	17	-04	00	-01	01	00
6	22	01	47	-03	09	03	09	08	-01	00
7	00	00	05	59	-07	02	09	-01	02	-03
8	04	28	-06	71	02	-03	01	05	00	08
9	-02	20	01	06	74	-04	-04	-02	06	04
10	-02	05	03	-07	74	02	-04	02	-01	-06
11	-03	06	00	00	-01	56	00	00	-07	-08
12	-01	-07	-01	00	16	50	19	-13	04	00
13	06	27	-04	-05	24	20	01	32	-01	22
14	-01	10	-02	05	13	48	00	12	00	34
15	03	28	21	04	-04	36	01	-04	02	38
16	03	27	-03	03	60	01	05	03	-01	17
17	02	10	-04	-07	02	15	41	12	30	-06
18	00	00	02	01	23	-06	31	51	12	00
19	-01	-02	05	-06	43	03	01	25	27	23
20	-02	04	-05	05	06	15	23	51	00	14
21	03	-02	04	03	01	-02	41	33	-09	37
22	-02	02	21	-01	13	38	-06	10	00	36
23	19	10	05	06	02	01	50	24	27	-05
24	03	07	-02	-02	21	43	12	02	08	09
25	-02	-07	00	07	-07	09	49	40	20	07
26	00	01	20	03	-03	-02	43	01	41	-05
27	-07	20	00	00	01	23	33	04	10	24
28	05	01	00	-07	03	21	50	-05	-02	17
Σ	151	282	240	193	388	356	406	284	204	265

* The decimal point has been omitted for all entries.

TABLE 5
The Final Transformation Matrix

	M	P	R	N	V	W	F	K	C	E
I	.12	.22	.15	.13	.25	.24	.26	.20	.12	.17
II	-.19	-.16	-.35	-.36	.33	-.20	.45	.33	.16	.02
III	.01	.01	.54	-.59	-.20	.45	.15	.23	-.09	
IV	-.13	-.17	-.28	-.18	-.39	.65	.00	.09	.22	.21
V	-.13	.17	-.54	.30	.23	.34	.13	-.44	-.11	-.22
VI	.52	-.18	.29	-.27	-.18	-.10	.44	-.40	.35	-.53
VII	.18	-.11	-.41	.60	.40	-.51	-.33	.21	.57	-.02
VIII	.25	-.76	-.31	-.04	.10	.22	.22	.31	-.30	-.05
IX	-.45	-.05	.18	.02	.18	-.01	-.27	.10	.09	-.71
X	.58	.50	-.82	.00	-.18	.08	-.30	.56	-.55	-.30

TABLE 6
Cosines of Angles between Reference Vectors

	M	P	R	N	V	W	F	K	C	E
M	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....
P	.07	1.00	.....	.....	.....	.....	.....	.....	.....	.....
R	-.08	.10	1.00	.....	.....	.....	.....	.....	.....	.....
N	.02	.19	-.28	1.00	.....	.....	.....	.....	.....	.....
V	-.20	-.08	-.24	.02	1.00	.....	.....	.....	.....	.....
W	-.10	-.02	-.17	-.31	-.24	1.00	.....	.....	.....	.....
F	.11	-.33	.05	-.18	-.21	.08	1.00	.....	.....	.....
K	.20	-.01	.33	.06	.04	-.09	-.16	1.00	.....	.....
C	-.18	-.23	.11	.27	.09	-.38	.23	-.23	1.00	.....
E	-.13	-.02	-.08	-.02	-.02	.15	.03	.10	-.01	1.00

TABLE 7
Correlations between the Primary Vectors

	M	P	R	N	V	W	F	K	C	E
M	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....
P	.06	1.00	.....	.....	.....	.....	.....	.....	.....	.....
R	.12	-.16	1.00	.....	.....	.....	.....	.....	.....	.....
N	.02	-.24	.44	1.00	.....	.....	.....	.....	.....	.....
V	.23	.06	.37	.23	1.00	.....	.....	.....	.....	.....
W	.22	.01	.38	.31	.35	1.00	.....	.....	.....	.....
F	-.18	.26	.08	.19	.22	-.03	1.00	.....	.....	.....
K	-.13	.10	.32	.06	.10	.24	.14	1.00	.....	.....
C	.20	.24	-.08	-.29	-.03	.32	.25	.20	1.00	.....
E	.14	-.02	.02	-.01	.01	-.13	.04	-.14	-.04	1.00

TABLE 8
The Factorial Pattern*

Test No.	Test Name	M	P	R	N	V	W	F	K	C	E
1.	First Names	59	....	....	....	....	....	....	....	....	....
2.	Word-Number	34	....	....	30	....	....	....	....	35	....
3.	Identical Numbers .....	....	49	....	....	....	....	....	....	....	....
4.	Mirror Reading .....	....	....	55	....	....	....	....	....	....	....
5.	Letter Series .....	....	....	49	....	....	....	....	....	....	....
6.	Letter Grouping .....	....	....	47	....	....	....	....	....	....	....
8.	Multiplication .....	....	....	....	71	....	....	....	....	....	....
7.	Addition .....	....	....	....	59	....	....	....	....	....	....
9.	Same or Opposite .....	....	....	....	....	74	....	....	....	....	....
10.	Completion .....	....	....	....	....	74	....	....	....	....	....
16.	Disarranged Sentences .....	....	....	....	....	60	....	....	....	....	....
19.	Paired Opposites .....	....	....	....	....	43	....	....	....	....	....
11.	First & Last Letters .....	....	....	....	....	....	56	....	....	....	....
12.	Suffixes .....	....	....	....	....	....	50	....	....	....	....
14.	First Letters .....	....	....	....	....	....	48	....	....	34	....
24.	Given Letters .....	....	....	....	....	....	43	....	....	....	....
22.	Number of Letters .....	....	....	....	....	....	38	....	....	36	....
15.	Anagrams .....	....	....	....	....	....	36	....	....	38	....
28.	Theme .....	....	....	....	....	....	....	50	....	....	....
23.	Topics .....	....	....	....	....	....	....	50	....	....	....
25.	Sentence Fluency .....	....	....	....	....	....	....	49	40	....	....
26.	Things Round .....	....	....	....	....	....	....	43	....	41	....
21.	Unfinished Stories .....	....	....	....	....	....	....	41	33	....	37
17.	Adjectives .....	....	....	....	....	....	....	41	....	30	....
27.	Things to Eat .....	....	....	....	....	....	....	33	....	....	....
18.	Similes .....	....	....	....	....	....	....	31	51	....	....
20.	Letter Star .....	....	....	....	....	....	....	....	51	....	....
13.	Synonyms .....	....	....	....	....	....	....	....	32	....	....

* The decimal point has been omitted for all entries. Only loadings of 30 or higher are entered in the table.

REFERENCES

1. Carroll, John B. A factor analysis of verbal abilities. *Psychometrika*, 1941, 6, 279-307.
2. Carroll, John B. The factorial representation of mental ability and academic achievement. *Educ. psychol. Meas.*, 1943, 3, 307-332.
3. Cattell, Raymond B. Temperament tests. I. Temperament. *Brit. J. Psychol.*, 1932-33, 23, 308-329.
4. Cattell, Raymond B. Temperament tests. II. Tests. *Brit. J. Psychol.*, 1933-34, 24, 20-49.
5. Cattell, Raymond B. *A guide to mental testing*. London: Univ. London Press, 1936.
6. Coombs, Clyde H. A criterion for significant common factor variance. *Psychometrika*, 1941, 6, 267-272.
7. Goldstein, K. The problem of the meaning of words based upon observation of aphasic patients. *J. Psychol.*, 1935, 2, 301-316.
8. Hargreaves, H. L. The "faculty" of imagination. *Brit. J. Psychol.*, Monograph Supplements, No. 10. Cambridge: Cambridge Univ. Press, 1927.
9. Huber, Mary. Re-education of aphasics. *J. speech Disorders*, 1942, 7, 289-293.
10. Johnson, D. M. and Reynolds, F. A factor analysis of verbal ability. *Psychol. Record*, 1941, 4, 183-195.
11. Lashley, Karl S. Coalescence of neurology and psychology. *Proc. Amer. philos. Soc.*, 1941, 84, 461-470.
12. Nielson, J. M. *Agnosia, apraxia, aphasia: their value in cerebral localization*. 2d ed. revised. New York: Paul B. Hoeber, Inc., Medical Books, Harper Bros., 1946.
13. Notcutt, B. Perseveration and fluency. *Brit. J. Psychol.*, 1943, 33, 200-208.
14. Stephenson, W. and others. Spearman factors and psychiatry. *Brit. J. med. Psychol.*, 1934, 14, 101-135.
15. Studman, L. Grace. Studies in experimental psychiatry. V. 'w' and 'f' factors in relation to traits of personality. *J. ment. Science*, 1935, 81, 107-137.
16. Thurstone, L. L. *Multiple-factor analysis*. Chicago: Univ. Chicago Press, 1947.
17. Thurstone, L. L. *Primary mental abilities*. Psychometric Monographs, No. 1. Chicago: Univ. Chicago Press, 1938.
18. Thurstone, L. L. An experimental study of simple structure. *Psychometrika*, 1940, 5, 153-168.
19. Thurstone, L. L. A single plane method of rotation. *Psychometrika*, 1946, 11, 71-79.
20. Thurstone, L. L. and Thurstone, T. G. *Factorial studies of intelligence*. Psychometric Monographs, No. 2. Chicago: Univ. Chicago Press, 1941.
21. Weisenberg, Theodore and McBride, Katherine E. *Aphasia, a clinical and psychological study*. New York: The Commonwealth Fund, 1935.

A NOTE ON THE REFLECTION OF SIGNS IN THE EXTRACTION OF CENTROID FACTORS

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This note suggests that the reflection of residuals in the centroid method of factor analysis should be continued, whenever possible, after all the sums of the columns in the correlation matrix, excluding diagonal values, are positive. A criterion is given for determining whether further reflection is possible in such cases.

It is the purpose of this note to offer a suggestion in regard to the reflection of residuals in the centroid method* of factor analysis. It is suggested here that the reflection of residuals should be continued, whenever possible, after all the sums of the columns in the matrix, excluding diagonal values, are positive. A criterion is offered to determine the possibilities of further reflection in such cases. The following rationale is offered in support of this suggestion.

Let us consider matrix A with variables a, b, c, \dots, n . We wish to determine, first of all, the effect upon the sum of all the correlations in the matrix (Σr) of reflecting variables a and b . We

r_{aa}	r_{ba}	$\Sigma r_a''$
r_{ab}	r_{bb}	$\Sigma r_b''$
$\Sigma r_a''$	$\Sigma r_b''$	C

* Thurstone, L. L. *The vectors of the mind*. Chicago: University of Chicago Press, 1935.

shall use the symbol $A\Sigma r_{ab}$ to indicate the amount of change in Σr which is due to the reflection of variables a and b . We shall use the symbol $\Sigma r_a'$ to indicate the sum of column a , not including the diagonal value r_{aa} . We shall use the constant term C to indicate that portion of the matrix which does not include any terms of variables a and b .

In reflecting two variables a and b , the signs of r_{ab} and r_{ba} will remain the same, since they are represented in both variables being reflected. We are concerned, therefore, with the portions of columns and rows a and b , not including the constant values r_{aa} , r_{ab} , r_{ba} , r_{bb} .

We shall consider, at first, the effect upon Σr of reflecting columns a and b . We shall indicate the sum of column a , not including r_{aa} and r_{ab} , by $\Sigma r_a''$. We shall indicate the sum of column b , not including r_{ba} and r_{bb} , by $\Sigma r_b''$.

Since each term in both columns is changed, the effect upon Σr of reflecting the two columns is

$$-2\Sigma r_a'' - 2\Sigma r_b''.$$

Since the rows are identical with the columns, the effect upon Σr of reflecting variables a and b is

$$A\Sigma r_{ab} = -4(\Sigma r_a'' + \Sigma r_b'').$$

Using the relationships

$$\Sigma r a'' = \Sigma r_a - r_{ab} - r_{aa}$$

and

$$\Sigma r a' = \Sigma r_a - r_{aa}$$

and substituting in the formula for the amount of change, we have

$$A\Sigma r_{ab} = 4(2r_{ab} - \Sigma r_a' - \Sigma r_b').$$

This last formula suggests a criterion for reflecting variables. From this relationship, it is obvious that Σr may be increased positively, even though the sums of all the columns, not including the diagonal values, are all positive. The only condition necessary for such an increase in value is that

$$r_{ab} > \frac{\Sigma r_a' + \Sigma r_b'}{2}.$$

This criterion is particularly useful after the usual reflections have been made and it is desirable to extract the maximum amount from the matrix for that factor.

It may be shown, in a similar manner, that the following general rule applies: The amount of change in $\sum r$ due to the reflection of n variables is equal to eight times the sum of all the correlations that will be reflected twice, minus four times the sum of all the column totals for those columns to be reflected, excluding the diagonal values.

In regard to a specific procedure, in the case of reflecting pairs of variables, it is suggested that one should:

1. Find the variable with the lowest column sum, not including diagonal values.
2. In this column and row, find the coefficients of correlation which have a higher positive value than the column sum.
3. Compare these pair combinations, using the criterion $r_{ab} > \frac{\sum r_a' + \sum r_b'}{2}$.
4. Reflect the two variables when the difference between twice the correlation and the sum of the two columns sums, excluding diagonal values, is both positive and maximum. $4\sum r_{ab}$ will be equal to four times this amount.
5. If the criterion is not met in the case of variable a , consider next the variable with the next lowest positive sum, excluding diagonal values. When the sums of the columns, excluding diagonal values, are reached which are higher than any possible coefficient of correlation, (as, for example, in the case when they are over 1) the possibilities for further reflection by pairs are exhausted.

This system will limit the procedure to the observation of only a few of the variables, and, at the same time, it exhausts the number of possible pair combinations in the total matrix.

An alternate system, which would be particularly useful in large matrices, would be to find two sums with low values and compare them with the correlation of the two variables in respect to the previously stated criterion. Pair combinations can be selected in this manner and then compared.

The reflection of variables in groups of three is not recommended as being generally practical, although the principles of procedure applicable to the reflection of pairs of variables apply to the reflection of three variables at a time.

P-TECHNIQUE DEMONSTRATED IN DETERMINING PSYCHOPHYSIOLOGICAL SOURCE TRAITS IN A NORMAL INDIVIDUAL

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P-technique, a method employing intra-individual correlation, is tried out for the first time. As part of the general design it uses some variables the same as those in a coordinated *R*-technique study and a second, parallel *P*-technique study with a clinical case. Definite factors are obtained among the psychological and physiological variables, which can be mutually matched. One is a fatigue factor, but the rest are general personality factors readily identifiable with those obtained in past *R*-technique researches.

I. Aims and Prerequisites of P-Technique

In 1943 it was suggested by Cattell (4) that functionally unitary personality traits, especially of dynamic modality, might be discovered by "temporal sequence studies," notably by employing a form of intra-individual correlation. Further consideration of this technique in the fuller perspective of the covariation chart (5) revealed it to have the promise of a systematic new approach, additional to, and perhaps as important as, the familiar *R*-technique, or its successor, *Q*-technique (3, 16).* It seemed appropriate, therefore, to call this intra-individual "correlation of occasions" *P*-technique, homologously with the older methods (7).

The general theory and research prospects in regard to *P*-technique have been set out in earlier publications (4, 7). Essentially it is a method for applying experimental measurement with co-varietational analysis to the single case. This means that one person must be measured on a collection of tests on a series of occasions. The analysis is then made on coefficients obtained from the correlations of traits in which the unit of entry is the day (or hour) of observation. The correlations can then be examined and analyzed to yield information either about *surface traits* (correlation clusters) alone, or, with more technical finish, about *source traits* (correctly rotated

*What is set out in references (3) and (16) may be briefly summarized by saying that in *R*-technique we correlated *test variables* with regard to a series of persons; in *Q*-technique we correlate *persons* with regard to a series of tests. In *P*-technique we again correlate *test variables*, but with regard to a series of occasions and within a single person. Practically all factor analyses yet published have been in terms of *R*-technique and the remainder in *Q*-technique.

factors). The functional unities thus revealed will be unique traits. Unique surface or source traits are of two kinds: (1) *intrinsic unique traits*, unique because they involve a dimension (quality) not found in any other individual, e.g., a sixth finger, and (2) *relative unique traits* (if the language specialist will forgive the juxtaposition) in which the unique trait has a pattern approximating a common trait. *P*-technique reveals relative unique traits. There is no need of a method to reveal intrinsic unique traits, which are in any case too rare for consideration.*

As indicated in the opening sentence, *P*-technique has particular promise in dynamic and clinical psychology, where it can, at least in principle, fully cope with those problems of discovering unique dynamic structure which some psychologists have claimed to lie beyond experimental and statistical approach. What remain to be cleared up, beyond these theoretical principles, are questions of the kind listed below, which require practical attempts with *P*-technique in research situations. The present pioneer study, and another directed specifically to a clinical case (10), have the purpose of (1) illustrating the method and (2) throwing light on personality structure, particularly with regard to the following questions:

(1) Does the relative unique trait approximate to the common trait in the same field? A factor analysis of the same, identical variables by *R*-technique, on a large group of people, is now in progress, so that factors may be compared with those already published here. An *R*-technique study of *approximately* similar variables already exists (6).

(2) How great is the scatter of relative unique traits about the central form, if the latter corresponds to the common trait? A factor analysis is also in progress on a second individual (10) chosen to be very different from the present one, and doubtless further instances will multiply to answer this question fully.

(3) Is *P*-technique more efficacious, as theory suggests, in yielding the pattern of dynamic traits than of other modalities? The variety of variables possible in a small study may or may not permit an answer to this.

* Actually there appear to be *three* senses in which uniqueness has been claimed for personality measurements. It would greatly aid clarity if the debaters would indicate which sense is intended. They are: (1) uniqueness of individual personality as a unique combination (pattern) of *common* traits. This has been pointed out, in reply to Allport's contention that factors cannot do justice to uniqueness, by Wolfe and others (7); (2) uniqueness of the form (loading pattern) of the trait by which the individual is to be measured. This may be due to either (a) intrinsic uniqueness arising from an entirely new dimension in the individual or, (b) relative uniqueness, as a divergence of the trait from the common pattern, as indicated above.

Since the first theoretical presentation (4) and discussion (5, 7) of *P*-technique there has been no experiment which could be taken as an illustration of its working except possibly that of Baldwin (2) which was apparently conceived in a different theoretical framework. Prior to factor analysis (or without its employment) there have, however, been quite a number of experiments collecting measurements on various functions on a single individual from day to day, notably that of Dodge (12). It is possible that some of the data reported in these studies could be analyzed in the present more complex frame of reference to answer the newer questions propounded above. Baldwin's data do not immediately throw light on these questions because of the differences between his approach and that required by *P*-technique. In the first place his variables have not been chosen to constitute a complete sampling of the personality sphere, such as might encompass the principal personality factors found by *R*-technique, and, in the second place, his factors are not finally rotated, regardless of orthogonality, for simple structure. These methodological differences, in a study excellent within its own framework, prevent any fruitful comparisons of our results or any attempt to obtain confirmation from his results of the well-known *C*, *E*, and *F* personality factors (to which his findings have some faint resemblance) found in *R*-technique.*

Some theoretical considerations of a narrowly statistical nature remain to be considered in developing this new method, but it would be inappropriate to debate these in any detail until the basic questions have been answered. The latter concern whether the correlations obtained in this way transcend chance error, whether they yield factors having psychological meaning and interest, and whether the factors are of the same general nature as the *R*-technique personality factors. Some statistical conditions scarcely need discussion; for example, in using the product-moment formula the measurements must have the same closeness to a normal distribution as is required for *R*-technique.

The principal new problem concerns whether systematic trends in the measurements as they are made from day to day—trends running in one direction from beginning to end, such as might be associated with learning, maturation, or seasonal effect—should first be partialled out as "extraneous" to personality study. At least in an initial study of this kind the writer is quite opposed to partialling out

* It is perhaps of historical interest that Baldwin appears not to have viewed his experiment as an example of *P*-technique, cognate with the *R*- and *Q*-techniques. He regards his procedure, mistakenly in the writer's opinion, as a statistical derivative of an earlier approach studying frequency of association of responses in a single individual (1). His contribution to personality study in the latter is a completely novel method, *sui generis*. To conceive correlation within the single individual in this frame of reference is to miss the wider scope and flexibility of *P*-technique.

trends. It is better to factorize the untouched matrix and deal with trend factors as such if they appear. Any factor showing a high loading with a measure of sequential order of experiments *may* be a learning or maturation factor only. On the other hand it may be a true personality factor in which, through circumstances, there has been a continuous development during the period of experiment. For example, the *C* factor of Integration vs Neurosis might show such a trend during a course of psychotherapy.

To anticipate momentarily our findings, let it be said that we found no such global trend factor. On the other hand, we did find a factor highly loaded with the hour of the day at which experiments were carried out. This proved to be a fatigue factor, readily distinguishable from personality factors by its negligible loading in any trait permanently in personality.

In conclusion the reader should be reminded that the full evaluation of the present method can be gained only by comparison of the present results with those of two other researches, one in *R*-technique (11), one in *P*-technique with an "abnormal," clinical case (10), which were planned as part of a total study on the new method. These studies have, however, been carried out (and published) independently in order that the findings as such may not be mutually influenced. They are independently founded pillars, which may or may not prove suitable to support the hypothetical general conclusion.

II. *Description of the Experiment*

a. *Subject and Setting*.—The subject was a "normal" adult, not deviating noticeably from the average except in intelligence. She was a 29-year-old woman, formerly a university instructor, engaged in domestic duties during the time of this experiment.

Each day for 9 weeks (55 days, owing to week-end interruptions), running from the 22nd of April to the 19th of June, 1946, the subject was (1) measured on the same batch of test variables, (2) rated by close observers on personal behavior, and (3) self-rated on a personality questionnaire. The sessions were held at times scattered as evenly as possible over the day from 8 A.M. to 10 P.M., in order to establish the diurnal pattern of fatigue.

b. *Description of Variables*.—

(1) *Objective tests*.—The choice of objective tests was determined by (a) the need to coincide with the *R*-technique study, in which tests most promising as measures of personality factors were selected; (b) the requirement that the same form of test could be re-administered again and again. This eliminated some of the more

interesting tests from (a).

1. *Salivary pH* (2).*—Measured, *positively for alkalinity*, by a standard pH meter.

2. *Disposition Rigidity or Perseveration* (8).—Two sub-tests only. (a) Same sentence written with forward (normal) and with backward movement of pencil; (b) multiplication of numbers in ordinary way and multiplication in which letters stand for numbers. The sentence and the code were altered every day. Speed of the old activity was divided by speed of the novel activity, according to disposition rigidity findings (8). One minute was spent on each of four activities. The second and novel test was rejected later as not correlating with the standard motor rigidity test.

3. *Myokinesis* (4).—The work of Johnson (13) and of Mira (14) suggests that magnitude and variability of movement may relate to surgency-desurgency (*F* factor) or to emotional adjustment (*C* factor). As in Mira's technique, *S* with eyes closed drew left-handed four rows of ten lines side by side with the stroke (a) downward (b) upward (c) downward (d) upward. (a) and (b) were estimated to be one, and (c) and (d) two inches in length. The mean length of line in four rows was used here, though other indices will be tested later.

4. *Reaction time* (5).—To light in dark box: (a) ten with a warning signal two seconds before light; (b) ten with irregular warning interval of 1 to 3 seconds; mean of both.

5. *Ratio of Reaction Times* (6).—Mean time for regular warning divided by time with irregular warning.

6. *Fluency and Thematic Apperception* (7).—(a) Words in one minute completing a story indicated by an opening sentence (different each day); (b) words in two minutes in one T.A.T. picture when instructed to make a dramatic story; (c) drawings in one minute on each of two fluency cards (7).

7. *Reversible Perspective* (3).—Uncontrolled cube reversal, number of reversals in two minutes' fixation.

8. *Psychogalvanic Reflex Resistance* (not finally factorized here.) Absolute resistance 15 minutes after being connected to apparatus.

* The number in parentheses refers to the number of this variable in the factor table, page 284.

9. *Psychogalvanic Reflex Deflection Frequency* (11).—Number of deflections (greater than a 5% minimum magnitude) while idly looking into dark box for three minutes.

10. *Psychogalvanic Reflex Mean Deflection* (10).—To (1) loud sound; (2) electric shock; (3) effort of learning; and (4) recalling word list: worked out as per cent loss of resistance.

11. *Psychogalvanic Reflex Upward Drift* (12).—*S* left relaxed with instruction "No more shock." Recovery of resistance, as upward drift, over 30-second interval, immediately after shock.

12. *Endurance (not factorized)*.—Position on dial at which *S* reported mounting electric shock was becoming unbearable. This *S*, on the apparatus used for the men and women in the *R*-technique study, was unfortunately in the minority which reached the "ceiling" of the shock strength without protest. Consequently we recorded instead the "cost" of this endurance in terms of P.G.R. resistance drop and subsequent rise.

13. *Suggestibility* (9).—The sway test as used by Hull, Eysenck, and others and suggested by Eysenck (13) to correlate with *C* factor (general neuroticism and emotionality): (a) inches forward minus backward when phonograph record suggests "falling forward, falling forward"; (b) inches backward minus forward with suggestion "You are beginning to fall backward," similarly for one minute.

14. *Memory Total* (14).—While attached to the P.G.R., *S* was asked to memorize as many as possible of 18 words, of which 6 were emotionally colorless (table, street) and 12 emotional (3 elation, 3 frustration-anger, 3 fear, 3 depression). One minute was allowed, permitting at least four readings. Recall was tested five minutes later, 20 seconds being allowed.

15. *Memory Ratio Emotional to Non-Emotional* (13).—Ratio of emotional to non-emotional words in 13. A new list of words was made out each day.

These tests were given in the order indicated, except 14 and 15, where memorizing occurred after 9 and recall after 10.

(2) *Behavior ratings*.—While it would be very relevant to include ratings on various dynamic interests, the necessity of confining ourselves to about a dozen variables inclined us to choose the primary personality source traits (7), by which the whole personality sphere can be covered. Some of these are probably dynamic, and in any case we also had records of dreams and daily activities which could later be analyzed into dynamic interests.

Each of ten factors (Factor *B*, Intelligence, and the doubtful *L* factor were omitted) was rated immediately before the experiment, on behavior of the preceding two hours, by the experimenter and the husband of the subject, on a graphic scale. The definitions were as given elsewhere (7). However, it is important to remember that these ratings could not be reliable assessments of the whole factor but only of specific behavior central to the factor. For example, cyclothymia was assessed mainly on "easy-going cooperativeness."

1. *Factor A.* Cyclothyme vs schizothyme. Principally easy-going cooperativeness versus obstructiveness.
2. *Factor C.* Emotional steadiness vs general emotionality and neuroticism.
3. *Factor D.* Hypersensitive, sthenic emotionality vs phlegmatic frustration tolerance. Principally excitable, attention-getting behavior.
4. *Factor E.* Dominance vs submissiveness.
5. *Factor F.* Surgency vs. desurgency. Principally cheerfulness, placidity, talkativeness vs worried, depressed.
6. *Factor G.* Positive character vs immature dependence. Principally perseverance, persistence, and will qualities.
7. *Factor H.* Adventurous cyclothymia vs withdrawn schizothymia. Principally friendly, outgoing behavior vs shyness, withdrawal.
8. *Factor I.* Sensitive, anxious, imaginative emotionality vs rigid, tough poise. Principally as jumpiness and over-reaction socially vs poise.
9. *Factor J.* Vigorous, determined character vs neurasthenia.
10. *Factor K.* Intellectual, cultured mind vs boorishness. Principally rated as keenness of intellectual interests and analytical vigor of mind on the day in question.

(3) *Self-Ratings.*—The principal factors discovered in questionnaires, by Guilford, Vernon, Reyburn, Taylor, and others have been summarized elsewhere (7) by Cattell and equated, on the basis of meaning and the meagre empirical evidence yet available, to the principal external behavior factors. As an inquiry on the soundness of this matching, each of the behavior factors used in the study was represented also by one of these questionnaire factors, the two highest-loaded questionnaire items being employed for this purpose. The ratings of the two observers and the self-ratings by the subject through the questionnaire items were, however, thrown together, as indicated below, only when all three intercorrelations showed adequate reliability. This occurred in all but two of the factors. Two questionnaire factors represent factors not known in be-

havior ratings. The subject answered all these questions at the beginning of each session, not by "Yes" or "No," but by a mark on a graphic scale.

It was planned, wherever possible, to pool the inner and outer (behavior-rating and self-rating, questionnaire) estimates of each factor (giving equal weight to each), in order to begin the factor analysis with fewer and more reliable variables. The pooling was carried out, however, only when all three correlations (between the two raters and the self-rater) were positive and significant. In all cases the correlations were positive and rather low, but no lower than might be expected from an intrinsically very valid measure based on only a two-item questionnaire. The highest was .90, the median .43, the lowest .05. The lowest r 's were not between the observers but between the self-rater and the observer, and might be due to the inner and outer factors not being perfectly matched.*

III. Analysis of Objective Test Patterns

In any factor analysis designed to give perspective on over-all personality patterns—an important objective in a first *P*-technique study—it is desirable (a) to have the whole personality sphere represented and (b) not to have some variable representing, alone, a whole factor while other factors are represented by many variables, for in this way first- and second-order factors may be confused. The first is assured by basing our approach on previous factorization of the personality sphere. To meet the second condition, and also for economy of factorization labor, it was decided to factorize the objective tests first. The factors from the tests would then be factorized with the rating factors in a single matrix, to discover possible identities.

The objective test factors, after rotation for simple structure, are set out in Table 2 and the ensuing description.

One or two variables were omitted from the final factorization, notably the absolute P.G.R. resistance, because it seemed affected by sweating from hot weather for the whole of one week, and the memorizing, because the subject explained afterwards that she had em-

* The unsatisfactory variables were (1) *A*, in which the behavior ratings correlated only .17 and .18 with the questionnaire, though .66 with each other. We split this into *A*₁, self-rating and *A*₂, behavior rating. (2) *I* factor, all low but retained as a unity. (3) *D*. Sthenic-emotionality, similar. (4) *K* factor, like *A*, but here only the observers' rating was retained. (4). The two questions in QPIX (see 7) correlated only .07. Only that on daydreaming was retained, because the subject said she had no confidence in estimates of the goodness of her memory. It is interesting that the internal validities here were higher for those factors (notably *G*, in which the r 's were .89, .51, .90) where definition has been good and variance large in *R*-technique studies, than for those, notably *D* & *K*, which have been difficult to stabilize in *R*-technique (7).

ployed three different mnemonics at different times. The correlations both for memorizing and for ratio of emotional to non-emotional words recalled were, however, so consistent with respect to the factor pattern which appeared later that we discounted the subject's impressions and included it (by a secondary calculation from its correlations with highly loaded items in each factor. These were very consistent, but the loadings for these two items are naturally approximate).

Factor I. Emotional Abundance vs Emotional Dearth. — This loads high sway suggestibility and high P.G.R. deflection decidedly; and also, less highly, ratio of emotional to non-emotional recall, and upward drift on P.G.R. and frequency of deflections. It has no relation to time of day or sequence of experiments. Through these runs an emotional responsiveness to environment which might almost be called a dynamic vigor or readiness, were it not that sway suggestibility has been connected in the past with the more neurotic forms of emotionality.

Factor II. Physiological Ease vs Emergency Alertness. — Loads slow reaction time, salivary alkalinity, slow reversible perspective and, less clearly, poor memorizing, high ratio emotional to unemotional recall, low rigidity, and high ratio of regular to irregular warned reaction time. These variables are consistently and appreciably all negatively related to sequence of experiments, i.e., to practice.

Factor III. Fatigue vs Energy Reserve. — Loads time of day, quickness of reversible perspective, frequency of P.G.R. deflection, magnitude upward resistance drift during relaxation, and ratio of warned to unwarned reaction time. Except for the slightness of perseveration-rigidity loading (which, however, reaches significance in some rotations) these tests comprise known tests of fatigue and the factor is clearly one of diurnal fatigue.

Factor IV.—Uncontrol vs Inhibition. This loads Fluency, Perseveration-Rigidity, large movements in myokinesis and, less definitely, good memorizing, sway suggestibility, and P.G.R. Deflection. This factor is correlated positively with lateness of experiment sequence, but less so than II. Since rigidity (9), fluency (8) and sway suggestibility (13) have all independently been regarded as expressions of lack of integration and will (while large careless movements have the same character) it seems that this is definitely some kind of lack of inhibition, with greater spontaneity and carelessness.

The factorization which yielded these factors was intrinsically very satisfactory, first in that both McNemar's and Tucker's criteria showed definitely four factors, second in that the simple structure

was indubitable and clear-cut, and third in that simple structure, attained with unknown, numerically indexed variables, has led to certain meaningful factors. For example, time of day is central in III and is entirely absent from other factors, reaction time is wholly in II, Factor III is clearly diurnal fatigue, and so on. The obliquities of Factors I and IV and the novelty of other factors can therefore be accepted with confidence.

IV. The Principal Psycho-Physiological Source Traits in the Given Individual

The individual's level for each of the above factors on each occasion was worked out by adding the standard scores on the two or three highest variables in each factor.* These "objective test factors," as we shall call them, were next intercorrelated in a single matrix with the rated and self-rated primary personality factors. The general justification of this procedure is plain—we wished (1) to "place" the test factors in terms of known primary personality factors and (2) to begin to express and define the personality factors by definite objective measurements within the rough outlines of ratings. But the factorial problems which arise here need brief discussion.

The representation of the fourteen test variables by four factors in the final matrix is, of course, dictated largely by economy. If a test factor proves to be identical with a behavior factor, this will be revealed with reasonable certainty by the analysis. If, on the other hand, it belongs to a different universe or a different order, this also will be revealed as well by our present procedure as by lumping all variables together from the beginning.

An element of doubt arises only in so far as we are in doubt whether the factorization of the primary personality factors will yield primary or second-order personality factors. If our ratings of each factor were indeed absolutely pure measures of each factor, only second-order factors would emerge. To decide whether the test factors correspond to first- or second-order personality factors we should need only to observe whether (a) the direct correlations in the present matrix between test and rating factors or (b) loadings of the test factors in second-order factors, when corrected for attenuation, approximate unity. But our ratings are *not* pure measures of each primary factor and are presumably contaminated in various degrees with

* Factor I from suggestibility, P.G.R. deflection, and half P.G.R. rise.

Factor II from salivary alkalinity and slowness reaction time.

Factor III from time of day, speed reversible perspective, and half of reaction time ratio, P.G.R. deflection, and P.G.R. rise.

Factor IV from variability of myokinesis, magnitude of fluency, and rigidity.

other factors. Consequently it seems most likely that the factorization of the present personality factor matrix will actually yield first-order factors, each being "pointed" by high loading in the rated factor intended to represent it, but also involved to some extent in other "factor" ratings. This likelihood is increased by the fact that the personality sphere represented is likely to be widened through the inclusion of test and questionnaire variables. The examination of the correlation matrix before factorization revealed no correlations between test factors and behavior factors high enough to suggest identity, nor were the significant r 's of a test factor confined to one behavior factor.

The actual factorization again yielded four factors, according to both the Tucker and the McNemar criteria. However, in this case the presumption that more factors should be involved was so great and the indications of a factor special to three variables in the residual was so strong that we decided to extract a fifth factor, slight though it was, and attempt rotation with it. Again simple structure was obtained with unusual definiteness and inevitableness (over half the variables in the hyperplane) in the case of three factors. This occurred after four rotations in each. Another 25 rotations, however, were required to achieve simple structure on the two remaining factors, 1 and 5; and then, though satisfactory, they did not sit at comfortable angles near to orthogonality as did the first three factors. Rotation with the first four factors only yielded simple structure fairly readily with two, but eighteen more rotations were necessary to get simple structure with the remainder. Three of these factors are practically indistinguishable in loading pattern from Factors *A*, *F*, and *C* above. The fourth is also clearly the same as *G* above, but absorbs greater variance. The second cyclothyme factor *H* is therefore missing. These factors do not have such good hyperplanes as in the accepted rotation; in fact, only 60% of the number in the five-factor solution.

In view of the coincidence of the number of factors obtained—4 to 5—with the number obtained in two studies (7) of second-order personality factors, the first hypothesis to consider is that in spite of the reasons stated above these factors are indeed second-order factors. A careful comparison of the present loading patterns with those of the second-order factors (7) reveals no similarity whatever in two and a very distant similarity in the rest—so distant that, in conjunction with the absence of any resemblance in their intercorrelation, we feel justified in turning away confidently to the hypothesis originally suggested: that these are first-order factors. That this latter is true is witnessed by the ease with which the present factors—listed in Table 3 below—can be matched and identified with well-known primary personality factors from *R*-technique. We have only to set aside

for a moment our previous conception of the rated variables as factors and consider them simply as behavior rated according to the given definition, in order to see the present factors as familiarly patterned primary personality factors.

Let us first describe the factors, with labels, discussing the identifications in each case. We shall take them in diminishing order of magnitude (mean contribution to variance).

Factor 4. "C" Emotionally Stable Character vs Demoralized General Emotionality. The outstanding loadings are:

C+		C-	
Inhibition	vs	Uncontrol (Test factor 4) .....	.63
Steady	vs	Emotional .....	.50
Self-sufficient	vs	Not self-suf. (Self-rated) .....	.49
.....	vs	Daydreaming (Self-rated) .....	.47
Depressed (Solemn)	vs	Cheerful .....	.36

This is clearly the *C* factor of *R*-technique studies. Daydreaming as such did not figure in those variables, but it could be taken as the equivalent of "not facing life, subjective, evasive" (7). The presence of "cheerful" is rather surprising, but it evidently functions as the equivalent of "Frivolous" in the *R*-technique studies (7). Both are present only in very small loadings, but this confirmation throws new light on the nature of the *C* factor, indicating that its positive form has some sort of sobered, mature inhibition, as opposed to immature frivolous waywardness.

Factor 5. "H" Adventurous Cyclothymia vs Withdrawn Schizothymia. Loadings in:

H+		H-	
Friendly, interested in people	vs	Withdrawn, cautious, shy .....	.74
Emotional abundance	vs	Emot. dearth (Test factor 1) .....	.44
Cooperative, easy-going	vs	Obstructive .....	.37
Self-confident, dominant	vs	Submissive .....	.36
Sthenic emotionality	vs	Frustration tolerance .....	.23

It is interesting to note that two factors in the cyclothyme-schizothyme area are found here as in *R*-technique, but that there is no difficulty in distinguishing between them in the sense of the two factors of the earlier study. Here, as there, the second factor's schizothyme pole is distinguished by withdrawal ("shy" here; "aloof" in the original, 7). Also there is a lack of energy, adventurousness, and self-confidence. (Self-confident, dominant, sthenic here; ascendant, expressive, incontinent, opposed to retiring, quiet, narrow in the original, 7).

Factor 1. "A" Cyclothymia vs Schizothymia loads:

A+		A—	
Cooperative, easy-going	vs	Obstructive .....	.60
Friendly, interested in people	vs	Withdrawn, shy .....	.40
Daydreaming (self-rated)	vs	.....	.50
Vigorous	vs	Languid .....	.26
Jumpy, easily embarrassed	vs	Poised .....	.25

That this is the more simple cyclo-schizo pattern of the original *A* is shown by the emphasis on obstructiveness—indeed the variables originally chosen as straight representatives of *A* and *H* have come out as the highest loadings respectively in these factors. This factor seems to be the more general, generic one by the fact that there is little in it besides the loadings in the two original cyclo-schizo variables. That daydreaming should appear on the cyclothyme side is a little startling, but the subject explained that she rated herself not on any intensive compensatory phantasy life but on pleasant, relaxed musing which depended most on whether or not she was in a hurry! (Note also its appearance in *Surgency*, below). In this connection one notes that "optimistic" appears in the original cyclothyme factor patterns.

Factor 3. "G" Positive Character Integration vs Immature, Dependent Character loads:

G+		G—	
Persevering, strong-willed	vs	Quitting, fickle .....	.44
Self-sufficient	vs	Not self-sufficient .....	.42
Shy, cautious	vs	Friendly, interested in people .....	.40
Steady, stable	vs	Emotional .....	.37

That this second factor in the general realm of character is *G* rather than *C* is evidenced by persistence and self-sufficiency being high, while emotional stability, still in the pattern (as in *C*), is low. At first, it is a little surprising to find shyness and caution here, but in the original *R*-technique factor (7) "reserve" and "self-consciousness" appear at about this same level.

Factor 2. "F" Surgency vs Desurgency (or Hysteria-Dysthymia) loads:

F+		F—	
Physiological ease	vs	Emergency alertness (Test factor 2) .....	.53
Cheerful, talkative	vs	Depressed, worried .....	.37
Cooperative	vs	Obstructive .....	.34
Daydreaming	vs	.....	.32
Submissive	vs	Dominant, self-confident .....	.30
Steady emotionally	vs	Emotional .....	.30
Not self-sufficient (Sociable)	vs	Self-sufficient .....	.27

In this the slightest of factors, we have carried the listing to include items beyond the usual minimum of loading, in search of more complete definition. This factor is clearly surgency, but again day-dreaming seems a little misplaced and again "dominance" is likewise susceptible to slightly different interpretation. In the original, "co-operative" is perhaps equivalent to "responsive, genial, sociable," and "self-sufficient" (self-rating) to "set and smug," or "unsociable" (observer). In place of "dominant" (at the negative pole) we find "hostility" and in place of "submissive" the quality of being "adaptable and reasonable." In general, where these differences exist the *R*-technique studies must be accepted as giving the finer meaning, having been based on more defined variables, but one can at least match the meaning of the latter in the present coarse variables.

Additional evidence, if it were needed, of the above identifications is found in the fact that, except for the *F* factor and one specific correlation between *C* and *G*, the correlations between factors are of the same sign and general magnitude as exist among the corresponding *R*-technique factors (6). If these *r*'s are supplemented with those found among the direct estimates of factors, in the present original correlation matrix, giving, in all, 55 correlations among 11 factors, 42 of these are of the same sign as those found in *R*-technique. Twelve of the 13 dissident *r*'s arise from three factors only: *A*, *E*, and *F*. The possibility of such similarity by chance is not utterly remote, but the finding at least contributes a further independent probability in the direction of these *Q*-technique factors being the same as those of *R*-technique.

An important finding is that the pure test factors, with the exception of the first, align themselves directly with personality rating factors, so that each has zero loadings in all but one particular member of the latter. Whether these loadings in the particular factor reach the level necessary for concluding that test and rating factor are one and the same remains to be tested. Test Factor 2 emerges as the *highest* item in general personality Factor 2 and Test Factor 4 as the *highest* in the general personality Factor 4. (That they have the same numbers is accidental). The actual loadings, having regard to the reliabilities of our estimates of the test factors by simple addition of "sub-test" scores, are consistent with complete identification of Test Factors 2 and 4 with the corresponding over-all rating factors.

Test factor 3—general diurnal fatigue—does not correlate at all with Factors 1 through 4, are scarcely significantly with 5. That this one test factor should be quite unrelated to personality makes good sense when we realize that it is merely the daily repetitive cycle of fatigue. Test Factor 1 is unique in spreading over four factors,

though highest in that with which we should expect its nature (Emotional responsiveness) to make it cognate. Exploration of the possibility that this test factor is some more basic second-order factor reveals only a slight suggestive resemblance of pattern to second-order factor SH (7), but nothing convincing. The agreement of the meaning, and even of the label, of each of the Test Factors 1, 2, and 4 (assigned to them at a stage of the research long preceding the final factorization) with the behavioral meaning of the personality factors with which they identify, is strikingly good.

What requires explanation, in view of the very definite identification of these five *P*-technique with *R*-technique factors, is the absence of some six commonly found factors in *R*-technique. Factor *B*, general ability, is obviously absent because we included no intelligence-demanding tests. Dominance "*E*" is present only as a specific, in the rating variable set to estimate it, because Dominance is quite a narrow factor affecting only social aspects of personality (7). *D*, sthenic emotionality, has always been an elusive factor, insufficiently established by recent work even in *R*-technique. *J* and *K* are very slight factors, requiring populations of two or three hundred cases for their definition. Consequently we should not expect them here to acquire variance in anything but the variable specifically set to measure each. The only absentee for which no adequate cause is obvious is the Factor *I*, Anxious, imaginative emotionality vs Tough poise. In relation to the general population our subject is extreme in *I* and in *B*, but otherwise average. Possibly there is some connection.

The rather large correlation of *A* and *F* (positive) and of *G* and *H* (negative) may be peculiar to this subject. The exact correlation among factors in one subject promises a new source of personality uniqueness and one which may be of considerable diagnostic value. The first correlation might be interpreted, in view of our general observation of this subject, to mean that when she is in a cyclothyme, responsive adjustment-state she tends to shift toward the cheerful rather than the depressive group of emotions, at least in this life situation. The second may be a form of dynamic equivalence: that when more than average energy is available it shifts either into the carefree, adventurous sociability of *H* or into a heightening of persistent, serious application of *G*, so that they become inversely related. These and other more speculative hypothetical questions of the relation of physiological to personality factors will be taken up in a later paper, in which the day-to-day changes in these five factor measurements will be related to daily happenings, records of dreams, and clinical-type observations. Any fuller interpretation will be profitable, however, only when these findings can be aligned with those of the second

P-technique study and the *R*-technique study with identical tests, which form parallel studies in a single research plan.

V. Summary

(1) Day-to-day variations in personality traits are large enough to yield, with our present accuracy of measurement and behavior rating, significant correlations and definite factors, by *P*-technique.

(2) These factors give clear-cut simple structure and are then easily recognizable as well-known primary personality factors, as obtained by *R*-technique. The correlations *among* them tend to resemble, but do not so exactly match, those found in *R*-technique.

(3) Not all *R*-technique factors appear. However, it is interesting to find that the splitting of the cyclothyme-schizothyme "general syndrome" into two distinct factors *A* and *H*, and of general character integration into two distinct factors *C* and *G*, as indicated in Cattell's *R*-technique study, is born out here in *P*-technique. In *A* the schizothyme pattern emphasizes hostility and tension, in *H* withdrawal and inhibition. In *C* sober emotional maturity (as opposed to general emotionality) is emphasized, in *G* perseverance and vigor (as opposed to emotional dependence). The fifth factor is Surgency-Desurgency, *F*.

(4) Four clear-cut factors appear in the physiological and psychological tests. Two appear to be identical with personality factors *F* and *C*. Another is general diurnal fatigue. The last, (*I* in Table 2) Emotional abundance vs Emotional dearth, loading psychogalvanic response, ataxic sway under suggestion and P.G.R. drift and frequency, is principally associated with *H* (Adventurous cyclothymia vs Withdrawn schizothymia) but possibly shows a little relation also with *C*(+) and *G*(-). Factor *A* shows no relation to any physiological factor we measured, agreeing with an earlier tentative hypothesis that *A* is the environmental and *H* the constitutional factor in schizothymia.

(5) These results suggest new objective test batteries for five primary personality factors and help clarify the functional nature of these factors. However, these developments, as well as the answering of further theoretical issues in factorial personality analysis methods and the relating of the present factor variations to daily events, await the correlating of the present results with those of the two co-ordinated researches—one on *R*-technique, one demonstrating the value of *P*-technique for clinical practice.

TABLE 1
Factors in Self-Rating

Personality Factor Scored and Direction of Scoring	Questions Answered by Subject on Graphic Rating Scale
<i>A. Cyclothymia-Schizothymia</i> ("Yes" in negative direction)	1. Do you feel relatively shy and self-conscious today, so that you have tended to keep in the background on social occasions?
("Yes" negative)	2. Have you felt today that your mind has tended to move slowly so that you keep to one track in conversation instead of jumping about?
<i>D. Sthenic emotionality</i> ("Yes" positive)	3. Have you felt today rather easily excited and rattled in difficult situations?
("Yes" positive)	4. Do you feel unduly sensitive so that your feelings are easily hurt by remarks?
<i>F. Surgency-Desurgency</i> ("Yes" negative)	5. Have you felt depressed and miserable for no good reason or have you felt above average in spirits
("Yes" negative)	6. Have you felt unduly worried and tense today or not?
<i>C. Stable character vs General emotionality</i> ("Yes" negative)	7. Have you suffered today from periods of loneliness?
("Wrong" negative)	8. Is this a day on which everything seems to have gone wrong or on which things go well?
<i>QPX. Obsessional inflexible vs Asthenic QPV</i> See (7). Asthenic answer	9. Have you been daydreaming much today?
Negative in both	10. Has your memory been good today or poor and uncontrolled?
<i>E. Dominance-Submission</i> ("Yes" positive)	11. Have you felt today generally very self-confident or lacking in confidence?
("Others" positive)	12. When things have gone wrong today, do you think it has been mainly your fault or the fault of others?

TABLE 1 (Continued)

QP. VIIIa Self-Sufficiency See (7)

("Yes" positive)	13. Have you felt so absorbed in your work today that you have not noticed a need for company?
<i>G. Character integration-Dependence</i>	
("Above" positive)	14. Have you been above or below average in your persistence and perseverance today?
("Control" positive)	15. Do you feel that your emotional moods have been under very good control or not?
<i>I. Anxious emotionality-Poise</i>	
("Yes" positive)	16. Have you been rather easily startled and distracted by sudden sounds today?
("Insomnia" positive)	17. Did you fall asleep easily last night or did you suffer some degree of insomnia?
<i>K. Cultured mind vs Unintellectual</i>	
("Yes" positive)	18. Have you spent much time today in serious discussions, intellectual analysis, or not?

TABLE 2
Rotated Factors in Objective Psychological and Physiological Measures

Tests and Variables	Factor Loadings				h^2 *
	F_1	F_2	F_3	F_4	
Time of day .....	.02	.02	.71	-.05	.53
Salivary pH (alkalinity)	-.03	.56	.07	.00	.36
Reversible perspective, rapidity	-.17	-.43	.56	.09	.56
Myokinesis, size of lines drawn	-.18	.02	.03	.50	.48
Reaction time, length of	-.03	.75	-.09	-.04	.59
Reaction time, ratio regular to irregular	-.02	.28	.34	-.01	.24
Fluency of association (T.A.T.)	-.03	-.21	-.15	.55	.44
Perseveration (D. Rigidity) .....	.02	-.35	.12	.51	.47
Ataxic sway suggestibility .....	.75	-.02	.02	.35	.58
Size P.G.R. deflection .....	.73	.22	.30	.32	.65
Frequency of P.G.R. deflection .....	.27	.03	.48	.01	.29
Upward drift P.G.R. after stress .....	.39	-.14	.40	.01	.34
<i>Approximate Estimate Only</i>					
Ratio emotional to unemotional recall .....	.65	.40	.00	.00	
Efficiency memory-recall .....	.00	-.45	.00	.40	

Direction Cosines Among Factors

	F_1	F_2	F_3	F_4
F_1	.19			
F_2	.00	-.12		
F_3	.89	.06	-.26	

* Communalities expressed for original orthogonal axes.

TABLE 3
Rotated Factors in Personality Ratings and Measures

Variables	<i>F</i> ₁	<i>F</i> ₂	<i>F</i> ₃	<i>F</i> ₄	<i>F</i> ₅	<i>h</i> ²
1 Test Factor I. Emotional abundance .....	.05	-.18	-.32	.33	.44	.33
2 Test Factor II. Physiological ease vs Emergency alertness .....	.16	.53	-.03	-.01	.06	.32
3 Test Factor III. Fatigue vs Energy .....	.02	.02	-.07	-.06	.17	.19
4 Test Factor IV. Uncontrol vs Inhibition .....	.12	.00	-.06	-.63	-.07	.44
5 Factor A'. Cyclo-schiz. (Inverse of self- rated shyness, slowness)	-.13	.02	.06	.24	.19	.48
6 Factor A'. Cyclo-schiz. (Cooperative-Ob- structive) .....	.60	.34	.23	-.02	.37	.69
7 Factor C. Stable emotionally vs Emo- tional	-.03	.30	.37	.50	-.01	.70
8 Factor D. Self-sufficient, frustration tolerant	-.04	-.04	.02	-.07	.23	.77
9 Factor E. Self-confident, dominant vs Submissive, mild, retiring .....	.02	-.32	-.04	-.02	.36	.62
10 Factor F. Surgent vs Desurgent cheer- ful, content vs worrying, anxious .....	.04	-.37	-.23	-.36	-.02	.60
11 Factor G. Persevering, integrated, strong- willed vs Quitting, fickle	-.14	-.04	.44	.06	-.07	.87
12 Factor H. Advent. Cyclo-schiz. (Friend- ly, interested in people vs shy, cauti- ous) .....	.40	.05	-.40	.04	.74	.78
13 Factor I. Jumpy, easily embarrassed, over-active imagination vs Poised, tough, practical .....	.25	.03	-.07	.02	.24	.11
14 Factor J. Languid, absent-minded, as- thenic vs Vigorous, orderly	-.26	-.07	-.30	-.25	-.14	.73
15 Daydreaming tendencies .....	.50	.32	.06	-.47	.02	.46
16 Factor QPVIIIa. Self-sufficiency	-.19	-.27	.42	.49	-.06	.68
17 Factor K. Intellectual, analytical vs Un- interested in cultural matters	-.05	-.06	.06	.06	-.26	.47
Number of variables in hyperplane	7	9	9	9	7	
Mean variance due to factor .....	.060	.056	.058	.087	.076	

Direction Cosines Among Factors

	<i>F</i> ₁	<i>F</i> ₂	<i>F</i> ₃	<i>F</i> ₄	<i>F</i> ₅				
Factor 1. A: Cyclothymia-Schizothymia	<i>F</i> ₁								
Factor 2. F: Surgency-Desurgency		<i>F</i> ₂	.50						
Factor 3. G: Positive character integra- tion-Immature, Dependent			<i>F</i> ₃	.09	.18				
Factor 4. C: Emotionally stable char- acter-Demoralized general emotionality				<i>F</i> ₄	-.31	-.05	-.13		
Factor 5. H. Adventurous cyclothymia- Withdrawn schizothymia					<i>F</i> ₅	.33	.00	-.60	.21

TABLE 4
*Intercorrelations of Objective Tests**

Sequence no. of session	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hour of day	2	23													
Salivary pH	3	-58	17												
Reversal of perspective	4	64	44	-20											
Myokinetic size	5	77	02	11	26										
Reaction time	6	-40	04	36	-37	14									
Ratio reaction times	7	20	14	14	30	04	30								
Fluency	8	17	12	23	10	38	21	04							
Perseveration	9	70	14	-22	40	45	-28	12	18						
P.G.R. sway suggestibility	10	06	04	-20	-04	-27	-14	06	09	14					
P.G.R. mean defl.	11	-04	23	18	10	-03	04	09	07	07	55				
P.G.R. no. of deflns.	12	15	34	07	15	14	-03	09	-10	07	23	35			
P.G.R. upward drift	13	04	28	-05	17	0	-12	-04	-21	08	32	35	23		
Ratio emotional recall	14	-47	-21	27	-29	-07	18	14	10	-31	63	39	14		
Total recall	15	30	03	-10	29	17	-10	09	20	31	16	09	12	06	10

* Decimal points have been omitted from all entries in this table.

TABLE 5
*Intercorrelations of Ratings and Test Factors**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17							
Factor 1. Emotional Responsiveness	1																							
Factor 2. Relaxation		2	-11																					
Factor 3. Fatigue			3	14	-19																			
Factor 4. Uncontrol				4	-30	02	23																	
Cyclo-Schizo (Self-rating)					5	-18	-03	22	16															
Cyclo-Schizo Coop. vs. Obst.						6	-19	-10	-22	02	16													
Emotional Stability							7	07	09	16	-31	-50	-28											
Attention-getting, fussy								8	-15	14	-34	-10	56	33	-32									
Self-confident, dominant									9	-29	25	-16	-03	48	29	-13	58							
Cheerful, surgent										10	-16	17	03	-29	-37	-41	59							
Persevering, integrated											11	-01	15	-25	16	56	31	-50						
Adventurous, interested												12	-38	-17	-25	-15	25	49	-07					
Oversensitive, imaginative													13	02	-06	05	09	11	27	00				
Neurotic, languid														14	-05	-08	-24	-15	40	39	-28			
Daydreaming															15	02	24	-12	21	17	-18	-22		
Self-sufficiency (self-rated)																16	-11	29	-09	28	25	28	-60	
Intellectual interests																	17	09	-03	-23	09	41	21	-30

* Decimal points have been omitted from all entries in this table.

TABLE 6
Manner of Decline of Residuals in Main Factorization (Table 2)

Arithmetic mean of correlations before 1st factor extracted	=.242
Arithmetic mean of residuals after 1st factor extracted	=.128
Arithmetic mean of residuals after 2nd factor extracted	=.093
Arithmetic mean of residuals after 3rd factor extracted	=.074
Arithmetic mean of residuals after 4th factor extracted	=.064
Arithmetic mean of residuals after 5th factor extracted	=.059

REFERENCES

1. Baldwin, A. L. Personal structure analysis: A statistical method for investigating the single person. *J. abnorm. & soc. Psychol.*, 1942, 37, 163-183.
2. Baldwin, A. L. The study of individual personality by means of the intra-individual correlation. *J. Person.*, 1946, 14, 151-169.
3. Burt, C. L. *The factors of the mind*. London: University of London Press, 1940.
4. Cattell, R. B. The description of personality I. Foundations of trait measurement. *Psychol. Rev.*, 1943, 50, 559-594.
5. Personality structure and measurement. I. The operational determination of trait unities. *Brit. J. Psychol.*, 1946, 36, 88-103.
6. The description of personality II. Principles and findings in a factor analysis. *Am. J. Psychol.*, 1945, 58, 69-90.
7. *The description and measurement of personality*. New York: World Book Co., 1946.
8. *A guide to mental testing*. London: University of London Press. Revised Edition, 1947.
9. The riddle of perseveration. I. Creative effort and disposition rigidity. *J. Person.*, 1946, 14, 229-267.
10. Cattell, R. B. & Luborsky, L. B. P-technique demonstrated as a new clinical method for determining personality structures (In press).
11. Cattell, R. B. Confirmation and clarification of the primary personal factors. *Psychometrika*, 1947, 12, 197-220.
12. Dodge, Raymond. *Elementary conditions of human variability*. (Ernest Kempton Adams Fund for Physical Research, No. 10). Columbia University Press, 1927.
13. Eysenck, H. J. *Dimensions of Personality*. London: Kegan Paul. 1947.
14. Johnson, W. B. Euphoric and depressed moods in normal subjects. *Char. & Person.*, 1938, 6, 188-202.
15. Mira, Emilio. Myokinetic psychodiagnosis: A new technique of exploring the conative trends of personality. *Proceedings of the Royal Society of Medicine, Section of Psychiatry*, 1940, 33, 9-30.
16. Stephenson, William. The foundations of psychometry: Four factor systems, *Psychometrika*, 1936, 1, 195-210.

BOOK REVIEWS

ROBERT M. LINDNER and ROBERT V. SELIGER (eds.). *Handbook of Correctional Psychology*. New York: Philosophical Library, 1947. Pp. 691.

The stated purpose of this book, according to its editors, is to serve as a "source-book to which the institutional psychiatrist, psychologist, physician, case-worker, and administrator can turn for guidance in the performance of his functions." In the light of this rather ambitious goal, it is not picayune to call attention to a number of points germane to its achievement.

In the first place, a reference volume, such as this purports to be, needs an extensive index if it is to serve its ends effectively. The *Handbook* has none. In consequence, "the institutional psychiatrist, psychologist, physician" *et. al.* will find the book somewhat difficult to use. Secondly, the point of view dominating the work almost to the exclusion of all others is that of psychoanalysis. While no one would deny that this is one legitimate frame of reference within which to organize the data of rehabilitative work in prisons, it would seem necessary to point out to those who come to the book "for guidance in the performance of (their) functions" that there are other frames of reference. Failure to label the systematic approach basic to the book and acknowledge the fact that there are other approaches gives it a dogmatic tone and restricts its value as a source-book for prison workers. It would be easy to get the idea that the only sources of direction and information for the personnel of correctional institutions are the deep wells of Freud and his followers.

Third, among the forty-eight chapters of the volume, there is no section dealing with research methods or the place of research in penal institutions. This seems more than somewhat surprising in the light of three factors: (1) the editors' declaration that "correctional psychology is a relatively new specialty," (2) the research function which has been one of the unique contributions of psychologists in institutions generally, and (3) the obvious need for uncovering new knowledge about penal procedure and criminal rehabilitation that is stressed at various times in most publications, including this one, which are concerned with the topics.

Fourth, in its efforts to give wide coverage to the field, the book includes a few things that seem to bear little relationship to "correctional psychology." Two chapters on "The Intramural Practice of Eye, Ear, Nose and Throat" and "The Acute Medical Patient" have little to do with psychological or psychiatric matters except for a bit over a page in the latter article on the psychoses as acute illnesses. On the other hand, Appel's chapter on "Essentials in Helping People" is composed of superficial generalities without the grounding in prison situations which the announced goal of the *Handbook* would require.

Finally, there is the problem of how well much of the material here collected will meet the needs of the audience to whom it is directed. Intended for the professional personnel of correctional institutions, the information provided seems startlingly elementary. Gurvitz's paper (one of three by psychologist contributors, the others being Theodora Abel's chapter on "The Unstable Subnormal Girl in an Institution" and Lindner's contribution on "The Hypno-Analytic Technique with Prisoners") on "Psychometric Procedure in Penal and Correctional Institutions"

is typical and particularly relevant for psychologists. There is nothing in this chapter that would help any well-trained psychologist who came to the book looking for "guidance in the performance of his function." Worse, there is an uncritical and unqualified endorsement of the Rorschach test as occupying "a premier position" in the field of personality testing and a relative disparagement of the TAT on the ground that it "is as yet nowhere near the standardization achieved by the Rorschach" (pp. 64-65). There is probably little disagreement among the readers of *Psychometrika* that the term "standardization" as applied to projective techniques in their present state of development is at the very least a misnomer, regardless of how clinically useful such devices might be as variants of the psychiatric interview.

In spite of these damaging flaws, however, there is much between its covers that is of interest to psychologists. Rinck's paper on "Prison Medicine as a Specialty" is a good descriptive overview of prison hospital organization and the function of its psychological service. From the standpoint of professional relations, it is gratifying to see the psychologist's role defined by a physician administrator as that of "administering and interpreting the various psychometric and aptitude tests, as well as counseling inmates with personality problems" (p. 263).

In a chapter on "Electroencephalography: Use in Penologic Practice," Daniel Silverman brings together his previous work on EEG patterns in psychopathic personalities as well as a vast amount of work done on the same problem by other workers. From the standpoint of systematic coverage of a specific problem, this paper is perhaps the most valuable in the volume for psychologists. Silverman's cogent arguments and rather convincing evidence for an organic basis in psychopathy would have been much more meaningful, however, had his data been treated by more sophisticated statistical techniques than the tabulation of percentages; tests of the significance of differences between the EEG patterns of various diagnostic groups are very much in order.

More generally, the book is organized around the idea of the offender as a "criminotic," a unique individual whose criminal behavior is the result of dynamic motivants. As a consequent of this basic concept, for which indebtedness must be acknowledged to Arthur N. Foxe's paper on "Classification of the Criminotic Individual," emphasis is consistently on criminals as individuals who are candidates for medical and/or psychological rehabilitation. Stereotypes thus tend to be broken down and thinking diverted from concern with criminals as a group or class. That this is salutary from both a clinical and a social point of view there can be little doubt.

Finally, there is a good deal of material in the book concerning those disorders closely associated with criminal behavior. Three chapters on psychopathic personality by Diethelm, Cleckley, and Greenacre contain interesting syntheses of information about this psychiatric problem, and Wilder contributes a paper on "Sugar Metabolism in Its Relation to Criminology" that physiological psychologists will find valuable.

Of limited appeal to psychologists, especially those of a quantitative bent, the *Handbook* in forty-eight chapters covers the extensive field of prison medicine with special reference, of course, to prison psychiatry. It cannot be said that the aim of furnishing a "source-book to which the institutional . . . worker . . . can turn for guidance in the performance of his functions" has been attained.

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EDWARD JOSEPH SHOBEN, JR.

WALTER G. BOWERMAN *Studies in Genius*. New York: Philosophical Library, 1947. Pp. 343.

This study is patterned after the *Study of British Genius* by Havelock Ellis, which was originally published in 1904. The methods of analysis of data and the type of problems studied appear to be similar to those used by Ellis over 40 years ago. The author's primary objective was to study American "genius" in a study comparable to Ellis's study of British "genius."

Although the author attempts to define "genius" as "high intellectual ability," he really used the word as a synonym for "famous people." His study is based on the biographical data on the lives of 1000 deceased persons selected from the 1936 edition of the *Dictionary of American Biography*. The primary criterion used in selecting cases for the study was that of whether the person's biography occupied 1½ or more pages in the *Dictionary of American Biography*. No attempt was made to use "high intellectual ability" as a criterion in selecting persons for inclusion in the study.

The author states that the primary objective of the study is "to discover some of the biological characteristics—both as individuals and as groups of individuals—of Americans of high intellectual ability." The following outline of the contents shows his approach to this broad topic.

Chapter I is an introduction to the book. Chapter II presents a survey of the geographic origin of the grandparents of the "geniuses," drawing the major conclusion that "in the production of high ability those sections which got started first produced the most,"—i.e., areas settled first (New England, New York, Virginia, and Carolina) produced the largest numbers of famous people. Chapter III surveys the occupations of the "geniuses," concluding that most of them were professional people. Chapter IV surveys such factors as size of parental family, rank order in parental family, ages of parents at birth of "genius," and similar data. Chapter V reviews the education, travel, and childhood health of the subjects. Chapter VI reviews vital statistics on the marriages of the subjects,—age at marriage, number of children, proportion of boys to girls, and similar facts. Chapter VII presents data on length of life and the distribution of births and deaths by months. Chapter VIII concludes that more persons attain fame in time of war than in peacetime and that epidemics were not related to deaths of the group studied. Chapter X presents data on the height and weight of the group. Chapter XI studies pigmentation (eye and hair color) in relation to occupations of the group. Chapter XII attempts to summarize the book. There are seven appendices giving much of the "raw data" used in the studies.

The second part of the book is a very brief outline of similar data on "world-wide genius,"—based on 1000 persons from all parts of the world.

The techniques used in the study are open to criticism. The only "statistical" procedure used is the tabulation of distributions of data and the subjective comparison of these distributions with "expected" distributions. No attempt is made to determine statistically the significance or reliability of differences obtained between the "geniuses" and "normal" populations nor of any of the other differences obtained. In some instances the basis for deciding what distribution should be "expected" is not given or is obscure.

Many of the conclusions drawn by the author are open to criticism also. In some instances conclusions drawn appear to reflect the prejudices of the author despite evidence in his own study which contradicts his conclusions. For example, on page 56 he agrees with Havelock Ellis's conclusion that eminent persons tend to come from the upper classes only and states further, "Nor is there any sign

that the education of the proletariat will lead to a new development of eminent men." Yet on page 48 he notes that only 55 per cent of the fathers of his 1000 subjects were professional men and the others were in what he implies are the "lower occupational and social classes." In other instances lack of logic used in drawing conclusions casts a shadow of doubt in the reader's mind regarding the entire book. For example, in discussing the relation of temperament to disease, he writes: "... it should not be inferred from the life of artist Tryon that everyone of a stoical disposition may be expected to have cancer. But one may bear in mind the story of the typical Stoic, Greek boy, who had stolen a fox, which he was hiding within his garments. In accordance with the Stoic philosophy, he allowed the fox to eat away his intestines, rather than betray the fact of his theft. And so it does not seem improbable that people of a stoical disposition would include an overaverage proportion of sufferers from cancer."

This book was not intended to be any contribution to the field of psychometrics. It will be of interest to persons who study vital statistics of famous people. Psychologists will hesitate to use the conclusions drawn in this book until the data have been subjected to more adequate statistical analysis.

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FREDERICK B. DAVIS. *Utilizing Human Talent*. Washington, D. C.: American Council on Education, 1947.

This book was sponsored by the Commission on Implications of Armed Services Educational Programs. Its purpose was to outline the testing and classification procedures used by the armed services and to present the implications of these procedures for aptitude testing, guidance and counseling, and for admission and selection policies and practices in schools and colleges.

The book contains only two chapters. The first chapter contains a brief outline of the testing programs and classification procedures used by the armed services during World War II. This chapter is so brief that it is questionable whether it can be very meaningful to non-veterans. The primary objective of the chapter apparently was to establish the fact that the armed services used a variety of aptitude and proficiency tests in addition to education and work-history data in classifying each person for duty. Almost no data are presented regarding the validity of the procedures and tests used.

Chapter II, "Implications for Civilian Education," begins with the following statement: "Implications for civilian education may be derived from the selection and classification procedures used in the armed forces, but a consideration of them indicates that they are not new; they are, generally speaking, principles that have been advocated for many years by educators and psychologists." The correctness of this statement will be obvious to the reader of this review from the list of implications which follows. In fact, Davis would have been more correct if he had presented the following points as principles developed by psychologists and educators before the war which were utilized in organizing the selection and classification programs for the armed forces. At any rate, the person who is seeking for new ideas which originated during the war will be disappointed.

The ten "implications" which are presented by Davis are:

1. "Men and women of exceptional and specialized talent can be identified and trained." Davis advocates the viewpoint that a systematic, nation-wide pro-

cedure be developed for discovering talented persons and subsidizing the development of their talents.

2. "Effective educational and vocational guidance can be provided for students in schools and colleges."
3. "Tests of aptitudes required for success in various educational and vocational fields can be made available." The author emphasizes that the length and comprehensiveness of the differential aptitude tests required to provide a basis for choosing a vocation needs to be increased and that an adequate group of tests will be very lengthy. No matter how time-consuming the tests may be, they will be short cuts and time savers in preventing entry into training in which the examinee will not succeed.
4. "Combinations of highly specialized aptitude tests are more effective for purposes of educational and vocational guidance than tests of general intelligence or general learning ability." Davis advocates use of a set of aptitude tests which yields a set of several composite scores rather than merely a profile of comparable test scores.
5. "A test of fundamental academic aptitudes can be useful in educational guidance." Davis recommends the use of tests of factors such as verbal, reasoning, numerical, perceptual and spatial abilities, and memory.
6. "A test of differential aptitudes and interests can be useful in vocational guidance."
7. "Subjective evaluation of empirical data appears to add little or nothing to the accuracy with which personnel can be selected on the basis of suitable objective tests."
8. "The number of separate mental abilities that can be measured is very large."
9. "Regional evaluation of educational outcomes can be carried out on a wide scale."
10. "Objective tests may serve as an aid in selecting instructors."

The appendices will be of interest to psychometrists and statisticians. Appendix A contains three "implications":

1. "The importance of obtaining samples of known characteristics can hardly be overemphasized."
2. "Research on the effectiveness of aptitude testing and training procedures depends on the measurement of a satisfactory criterion."
3. "Validation data based on curtailed (selected) distributions may be markedly distorted."

Appendix B contains data on the derivation and use of formulas in dealing with these three problems:

1. "The effect on test validity of varying the reliability of equivalent items."
2. "The effect on test validity of varying the reliability of items that measure different mental functions."
3. "The effect on test reliability of varying the average reliability and intercorrelation of individual items that measure different mental functions."

The book will be of interest and value to three groups: (1) The appendices will be of interest to psychometrists and statisticians; (2) the discussion of "implications" will be of interest to school and industrial administrators as a summary of arguments favoring the use of tests for guidance and placement purposes; and (3) the discussion of "implications" will be of interest to novices in the testing field as a concise statement of widely accepted principles to be applied in testing work.

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